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Discussion of all papers is invited

Vol. 23 MAY, 1931 No. 5

AVOIDABLE WATER WORKS LOSSES[1]

By Frank C. Jordan[2]

The subject "Avoidable Water Works Losses," while always important, is of unusual importance during this period of depression, and the curtailment of unnecessary expenditures is vital to the well-being of public utilities, as well as to other commercial and industrial enterprises. Following the receipt of a request to prepare a paper on this subject, the writer sent inquiries to twenty men whose experience and training qualify them to speak with authority on this subject. This list included six engineers, five operators of privately owned plants, five operators of municipally owned plants, two editors of engineering papers and one college professor. Such a wealth of material was received as to make it necessary to select only a few of the outstanding avoidable water works losses otherwise the paper and the discussion would consume the greater part of the time set aside for this meeting. The thoughts and suggestions herein contained will be grouped according to the various departments of a water plant and some thought will be given to each part so that the paper may be of value to every water works man.

Acknowledgment is herewith made of the receipt of valuable information from the following well known water works authorities: George W. Biggs, Jr., Chief Engineer, American Water Works and

[1] Presented before the Indiana Section meeting, February 26, 1931.

[2] Secretary, Indianapolis Water Company, Indianapolis, Ind.

Electric Company, New York; Paul Hansen, Consulting Engineer, Pearse, Greeley and Hansen, Chicago; W. C. Hawley, Chief Engineer and General Superintendent, Pennsylvania Water Company, Wilkinsburg, Pa.; V. Bernard Siems, Executive Vice President and Chief Engineer, National Water Works Corporation, New York; J. E. Gibson, Manager and Engineer, Water Department, Charleston, S. C.; H. O. Garman, Consulting Engineer, Indianapolis; Arthur E. Gorman, The Pardee Engineering Company, Inc., Chicago; C. M. Osborn, City Manager, Wilmette, Illinois; Charles F. Ruff, Consulting Engineer with Malcolm Pirnie, New York; George W. Pracy, Superintendent, City Distribution Division, Water Department, San Francisco; C. M. Saville, Manager and Chief Engineer, the Water Bureau, Hartford, Conn.; S. M. Van Loan, Deputy Chief, Bureau of Water, Philadelphia; Charles Brossman, Consulting Engineer, Indianapolis, and several men of the Indianapolis Water Company.

This paper will be based on thoughts and suggestions contained in these letters, supplemented by suggestions from some of the operating force of the Indianapolis Water Company. It is the hope that this presentation will result in such a careful scrutiny of the construction and operation expenditures of water works properties as will produce that saving of which the water works fraternity can well be proud.

It has been well and truly stated that "the avoidable losses start with the original design of the plant, and the losses in existing plants are partly by reason of faulty design and partly by reason of operation." It is, therefore, highly desirable that every water utility be thoroughly studied at least once each year by a competent water works engineer, and after that the management should maintain a regular check of all construction and operation to see that they conform to recognized standards of service and economy. Such a procedure should be of great benefit to the community as well as the water plant owners.

SAVINGS IN THE FILTRATION PLANT

Mr. Biggs offers a valuable suggestion in reference to the possible saving in the use of coagulants by thorough mixing before coagulation and points out three plants in which there was an average reduction of 31 percent in the amount of sulphate of alumina used following the installation of mixing equipment. The importance of pre-

chlorination and also the introduction of ammonia is stressed by several of the writers, these men asserting that there was an improvement in the quality of water delivered from the purification plant as well as saving in the operating expenses.

Excessive washing of filters was cited as an instance of avoidable water works loss.

Mr. Ruff offers the following interesting comment in reference to a decided saving through the installation of a large coagulation basin:

In the design of the Providence filter plant, because of a favorable site, a coagulation basin was built having several days' storage instead of the customary eight hours' storage. The size of this basin was such that it did not have to be cleaned during the winter season and it was thus built without a roof. The general construction was very similar to that of any impounding reservoir and thus its cost was not in excess of the common type concrete coagulation basin with roof. As a result of the increased retention period for coagulation, it has been possible to cut the alum dose to a minimum. It is estimated that only about one-third as much alum is required as would be needed in a basin of ordinary size. In a plant treating an average of 25 m.g.d. this reduction in alum dose from 5,000 to 1,700 pounds per day amounts to something like $12,000 per year.

He also makes an interesting suggestion of a possible saving through the use of a single controller for three or four filter beds.

Unnecessary or unusual expenditures on filter plant construction received their share of criticism, the following being cited as an example of such unnecessary construction expense:

In a South American city the plans of a large filter plant to be built were examined, on which the cost was estimated at $3,200,000. A careful inspection of these plans showed that the same results could be accomplished and a plant designed in accordance with the most modern filter practice, that would cost approximately $2,200,000, or a saving of about one-third.

WELLS

Several valuable suggestions are made in reference to the intelligent design of wells, Mr. Siems citing the following interesting cases of savings through the proper development of well supply:

A great many water companies use wells as their only source of supply, additional wells being drilled and put in service as the demands of the system grow beyond the capacity of the existing wells. In many properties wells have been abandoned or never used, which when properly tested for capacity compared favorably with the other wells then in use. These wells were aban-

doned either because the original tests showed low capacity or because the flow from them decreases after a number of years of pumping. As a rule it is much cheaper to clean or retest such wells rather than drill new wells.

In numerous instances wells are found with the pumping equipment a considerable distance from the bottom of the well. By having the pump suction down as low as possible, the capacity of the well is usually increased. As an example of this, a well at Laurel Springs, New Jersey, (the water works being a subsidiary of the National Water Works Corporation) delivering 60 gallons a minute with an air lift system, delivering 400 gallons a minute with a deep well turbine pump.

At Lansdale, Pennsylvania, a well, being pumped by air-lift delivering 50 gallons per minute, showed an actual capacity of 115 gallons when pumped with a deep well centrifugal pump.

The proper development of a well supply will, in a great many cases, save fixed capital and also decrease operating expenses.

SAVINGS IN THE PUMPING STATION AND BOILER PLANT

It seems to be the consensus of opinion that the largest single loss in the average water plant is in its pumping costs, which in many cases are higher than necessary due to the use of improper equipment or to a decrease in the efficiency of the existing equipment. Mr. Siems well states that "in some cases improperly designed pumping equipment is installed which puts an added burden of operating cost on the Company, which in turn is passed to the consumer to the ultimate disadvantage of the community as a whole." He makes reference to the plants at Lansdale and Mt. Pleasant, Pennsylvania, where savings of approximately 40 percent on the investment were made by replacing steam driven with electric driven equipment.

Mr. Hansen makes reference to a city in which a saving of 50 per cent in pumpage costs could easily be made by the changing from steam to electrical power, which is available from hydraulic development at a very low cost. He also states that a great saving could be made by putting in better steam equipment and operating it more effectively. It is a regrettable fact, however, that the plant is municipally owned and political factors prevent the consummation of this much desired economy.

Mr. Hawley speaks of a substantial saving effected through the installation of an oil and waste saving machine and oil filter, referring to these as ordinary pumping station economies, but effecting a satisfactory reduction in operating expenses. He also comments on their installation of three new water tube boilers to burn powdered coal, each boiler being equipped with its individual pulverizer, the

new installation giving excellent service with an increase in station duty from 18 to 20 percent.

Mr. Brossman makes some very interesting comments on the importance of the purchase of coal which will give the greatest number of heat units per dollar, and the utilization of that coal in accordance with best operating standards. He makes the following lamentable comment in reference to the operation of some water plant boiler rooms:

Many small water works plants are operating boilers which are only giving 50 or 60 percent efficiency, and sometimes even lower. This is wasteful and without reason. These efficiencies should be brought up to around 65 or 70 percent, by hand firing, or even greater, if stoker equipment is used.

He makes the further interesting comment:

Station logs should be kept, showing coal consumption to water evaporated in the boilers, so that the maximum evaporation of water into steam can be obtained.

All such inefficiencies could be eliminated through proper engineering, but as has been well pointed out, much can be done through an aroused interest on the part of the operators of the boiler plants and pumping stations. This is exceptionally well pointed out in a paragraph from Mr. Ruff's letter which reads as follows:

An important point in eliminating waste around a plant is to let the personnel know what they are doing. Steam plants should be equipped with all gauges necessary to trace the heat in the coal all the way to the water delivered. The men should keep records not only of pressures and quantities, but of pounds of coal or killowatts per million gallons pumped; tons of coal per thousand pounds of steam, etc. In one plant with which I was connected we put in a large number of gauges and instructed the engineer to plot a daily curve showing the pounds of coal per kilowatt hour and the kilowatts per million gallons of water pumped. About a week later, no curve having been put on the bulletin board, I asked him about it. He said he was keeping the curve, but it looked so terrible he was ashamed to put it up. A week later, however, the plotting appeared on the board. For some time there was quite a variation up and down in the amount of coal per kilowatt and the other factors, but gradually the operating force managed to straighten this curve to a straight line within reasonable limits.

Mr. Gibson and others make references to pump slippage due to poor packing and this is generally characterized as poor supervision.

Mr. Ruff makes the following interesting comment in reference

to losses due to the use of centrifugal pumps with constant speed motors:

A common source of loss in pumping stations is due to the use of centrifugal pumps with constant speed motors. I know of one plant in which the pump was designed for 175 feet head but commonly pumped against a head of 125 feet. The manager of this plant having learned from the curves that the pump was most efficient at 175 feet had the engineer keep the discharge valve throttled down so that the gauge on the pump read 175 feet, thus, as he thought, securing the highest efficiency. The fact that 50 feet were thrown away at the discharge valve never seemed to strike him as a great loss. This pump was delivering water to a tank and the obvious solution was to run with the valve always wide open. Although under this condition the pump would not have as high kilowatt per water horse-power efficiency, it would pump more water for the current consumed which, after all was what was desired. Where centrifugal pumps pump direct to a distribution system, some storage should always be provided so that the pumps can run with the valves wide open. When a centrifugal pump is used in a situation where the head varies considerably, a variable speed motor should always be used. With a constant speed motor, if a pump is made to deliver the same quantity under half the head by throttling the discharge valve, the pump uses the same horse power and the same electric consumption as with a full head. The efficiency under this condition is just about half the efficiency at the higher head. With a variable speed motor the pump can be slowed down to a point where it pumps the desired quantity of water at the reduced rate with very nearly the same pump efficiency as before. Under this condition only half the horse power is required. The efficiency of the variable speed motor would fall off in proportion to its speed. Under this condition it would be perhaps 75 percent as efficient as before. This reduced efficiency, however, applies only to the power taken by the pump which is half the original power and consequently the kilowatt per water efficiency would be considerably more with the constant speed motor.

One of the writers suggests that some of the distribution systems are carrying unnecessarily high pressures thereby entailing avoidable losses. One case is cited in which the average pressure on a distribution system was between 100 and 125 pounds; the pumping expense $25,000 per year and the unaccounted for water approximately $10,000 per year. A reduction of 25 percent in the pressure resulted in a leakage reduct on of one-fourth and a saving of over $2,000 per year.

PIPE LAYING DEPARTMENT

References are made to the use of pneumatic tools for cutting pavements, rock, etc.; and for tamping back fill in trenches. Other labor saving devices in the Pipe Laying Department, such as the

"Baby Digger" manufactured by the Cleveland Tractor Company, etc., come in for their share of attention, it being pointed out that through the use of these devices the work is done better, quicker and at less expense than if done by hand labor.

The use of leadite or cement in the place of lead is stressed by two of the writers, being cited as great economies. Mr. W. C. Hawley makes the following comment in regard to the use of leadite:

The use of leadite for joint material in our cast iron mains has resulted in marked economy, not only in original cost but in leakage. Tests have shown leakage from mains laid with leadite of 5 percent and less of the allowable leakage under usual specifications for lead joints. We have been using leadite for 25 years and I can think of no other economy which has resulted in greater saving.

Mr. Ruff makes the following comment in regard to the use of cement:

The use of lead joints in distribution pipes is an avoidable loss, in our estimation, since better joints can be made with ordinary Portland cement. This is mixed very dry and caulked into the bell in the same manner as lead. On some jobs we have found the savings run as much as $100 per thousand feet of 8-inch pipe. Cement joints are used with perfect satisfaction in St. Petersburg and West Palm Beach, Fla., Des Moines, Iowa and San Antonio, Texas.

INSTALLATION OF SERVICE LINES

Mr. Hawley recommends the use of Anderson Mechanical Coupling for lead pipe, stating that this has not only resulted in a reduced cost per service, but has at the same time reduced their leakage. They do not permit the use of wiped joints, their experience being that the great majority of service line leaks are at wiped joints, whereas they seldom, if ever, have any leakage from the mechanical couplings. He further states that they are now using copper tubing for service lines and that they are finding it considerably less expensive than the heavy lead and more satisfactory in every way.

LEAKAGE—UNACCOUNTED FOR WATER

This subject receives much consideration, being referred to by practically every one of the men who answered my inquiries. "Flat Rates" come in for their share of condemnation, being cited as one of the outstanding "Avoidable Water Works Losses."

The importance of metering is stressed by several of the operators,

Mr. Hansen and others citing cases where the water consumption was materially reduced through the installation of meters, this reduction reaching in some cases as high as 50 percent. Mr. Hansen points out that in one case the saving prolonged the life of certain water works equipment, particularly the filters, for about twenty years.

Mr. Biggs cites the case of Little Rock, Arkansas, which reduced its pumpage per customer from 206,000 gallons per year to 136,000 gallons per year through the installation of meters.

Mr. Siems makes the following pertinent comment in reference to leakage:

> Leakage is something which is common to all systems. Any system which has a pumped supply should meter all consumers and know definitely each period the amount of unaccounted for water. Many leaks can be found by the water company's own men, and still further reduction in leakage may be accomplished by having a survey made by one of the standard leakage companies such as the Pitometer Company.

The Indianapolis Water Company can certify to the correctness of his statement in reference to the finding of leaks by the water company's own men. Our meter readers, whom I prefer to designate as representatives of the Water Company, are locating service leaks through the simple process of placing a flash light or screw-driver against the water line and listening, with ear to this instrument. If they hear a noise on the line they shut off the stop and waste, and if the noise continues they know there is a leak on the service line. In this way they can detect even a very small leak, and the saving which they have effected through this inspection has caused a satisfactory reduction in our pumpage.

During the past five or six years we have engaged in a metering program under which the public water supply of Indianapolis will be sold by measurement rather than the flat, or guess, rate. Approximately 90 percent of our accounts are now metered, and we expect to complete the job by the end of the year. We are unable to state definitely what the saving in pumpage will be due to the metering, but the studies of our Engineering Department indicate that the present savings are between 5 and 6 million gallons of water per day.

Mr. Brossman refers to one case where leakage was found which amounted to 12 percent of the entire pumpage due to a broken line crossing a river. The repairing of this leak caused a material reduction in the load on the pumps.

Mr. Garman states that it is his experience that when everything in the plant is thoroughly metered, and the customers are metered, and then the meters are well maintained, the losses are nearly eliminated.

Several of the writers make reference to the value of Pitometer surveys, Mr. Osborn stating that he has made two such surveys and that they have more than paid for themselves.

Mr. Siems states that the superintendent of water works at Reading, Pa., has two men who do nothing but look for leaks, and in four years these men have reduced the water input into the system

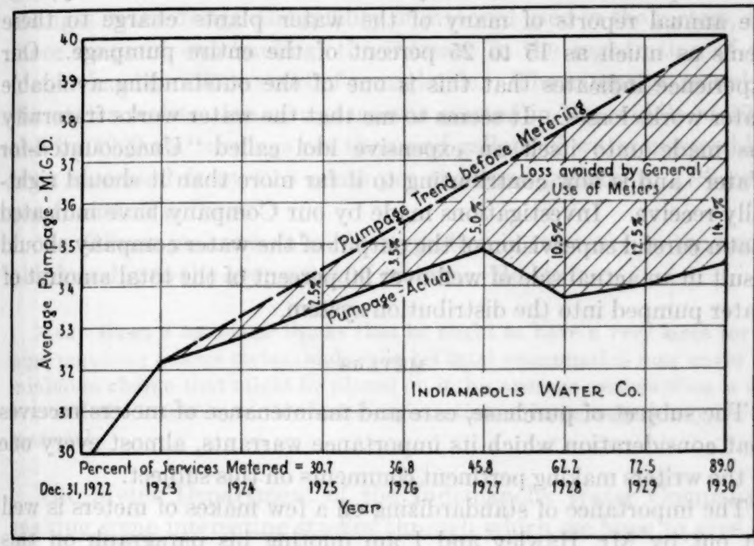

FIG. 1

from 18 million gallons per day to 13 million gallons per day. In addition to the saving in pumping and filtration expenses the savings of water has removed the necessity of making large expenditures which the City was planning in order to enlarge its pumping and filtering plants.

Mr. Saville states that all of the public water supply of Hartford, Conn., is metered, even public and semi-public property, and he believes that their percentage of unaccounted-for water is within reasonable limits. According to their last check-up the meters were recording within 15 or 16 percent of the total pumpage, the

unaccounted-for water including much water which was used for fire, sewer and street flushing.

This brings to mind the unnecessary use of water by the city. It is my opinion that a careful check in each city will disclose a very large unnecessary use by the city. The furnishing of so-called "free water" usually results in an unnecessarily high consumption to the benefit of no one. Our experience in Indianapolis has indicated that the metering of city water is followed by a material reduction in the demand with a consequent saving to the city.

The terms "Allowable Leakage" and "Unaccounted-for Water" have crept into the vocabulary of the water works fraternity, and the annual reports of many of the water plants charge to these items as much as 15 to 25 percent of the entire pumpage. Our experience indicates that this is one of the outstanding avoidable water works losses. It seems to me that the water works fraternity has made unto itself an expensive idol called "Unaccounted-for Water" and is now contributing to it far more than it should rightfully receive. Investigations made by our Company have indicated that a careful supervision of the output of the water company should result in an actual sale of well over 90 percent of the total amount of water pumped into the distribution system.

METERS

The subject of purchase, care and maintenance of meters receives that consideration which its importance warrants, almost every one of the writers making pertinent comments on this subject.

The importance of standardizing on a few makes of meters is well set out by Mr. Hawley and I am quoting his paragraph on this because of its interest to every water works man:

When I took charge of this plant I found some 20 different makes of meters in use which necessitated, of course, keeping 20 different kinds of repair parts, to say nothing of repair parts for the various sizes of each kind. A short time later we standardized on four makes of meters. Gradually we eliminated 3 of these and we are now using one standard make which, while not necessarily the lowest in first cost, is the one which has given us the best and most reliable service with the minimum cost of maintenance. As old meters have worn out they have been replaced with new ones of the standard make and we have already eliminated several of the original 20 different kinds. With the elimination of each one we have been able to cut down our stock of repair parts and so relieve the storekeeper of just that much work. Within a few years we should not have over 4 or 5 makes of meters in service. This will make a

material reduction in the work of keeping track of repair parts; of investment in repair parts; in the cost of maintenance, because the maintenance of some of these meters is excessively high and an increase in revenue due to the reliability, accuracy and sensitiveness of our standard meters.

Mr. Biggs makes some valuable comments in reference to under-registration of meters, citing the case of Wichita where a remarkable increase in revenue resulted from the elimination of this avoidable loss through under-registration of meters. The public supply of Wichita is hard and relatively high in chlorides. It has a very deleterious effect on meters, particularly the intermediate train gears and the measuring disc chambers. By a combination of certain changes in the design and quality of material used in the meters, and more frequent overhauling, the increase in the registration of the meters has been little short of remarkable. The campaign to reduce the under-registration of meters was started in the middle of 1923, and by 1929 the earnings per thousand gallons of water pumped had been increased from 12.5 cents per thousand gallons to 17.3 cents per thousand gallons.

Mr. Gibson makes a valuable suggestion in reference to the avoidable loss due to the over-sizing of meters. He states:

Many times a consumer thinks that he ought to have a very large service pipe requiring a large meter, and while his total consumption may cover any minimum charge that might be placed on it, his average consumption is very low and the loss due to the under-registration of large meters may become material.

The Meter Department of the Indianapolis Water Company is making some interesting studies through which we hope to give our customers adequate service, both as to volume and pressure, and at the same time retain for the Company *all* earned revenue. We recently installed a 2-inch Compounded meter on the service line for a 49-apartment, 7-story apartment building on N. Delaware Street, this meter being set in tandem with a 2-inch disc type meter. During the first three weeks following the installation, the 2-inch disc meter recorded 19,570 cu. ft.; the Compounded meter recorded 18,168 cu. ft. through the $\frac{5}{8}$-inch meter and 2,235 through the 2-inch meter, making a total of 20,403 cu. ft., or an increase of 833 cu. ft. over the 2-inch disc. The under-registration on the 2-inch disc type was 4.1 percent. It is interesting to note that the $\frac{5}{8}$-inch by-pass on the 2-inch Compounded meter recorded 89 percent of the total

flow in this 49-apartment building. These tests will be continued so that all inaccuracies may be eliminated, after which we will make a report which may be of special interest to all water works men. It will certainly stand as an indictment of over-sizing of meters.

We are also conducting some interesting studies in reference to the maintenance of our meters and are rearranging the shop layout so that the meters will move through the shop in a systematic manner. A new meter testing bench will permit the testing of 15 meters on one stream of water. Meter registers are now being run back to zero by a machine instead of by hand as formerly done. We are arranging to clean the meters with a solution manufactured by the Dearborn Chemical Company, Chicago, known as Special Treatment No. 134, this solution cleaning both the work parts and the exterior of the meter. This is not only a time saver, but it will at the same time eliminate much noise and dust, thereby creating better working conditions.

METER READING

Much has been written in reference to the proper utilization of the meter readers' time, but much remains to be done before there will be that utilization which approaches 100 percent. Studies made by the Indianapolis Water Company have indicated that the term Water Company Representative should be substituted for that of Meter Reader, and that the men whose duty it is to read the meters should then be schooled to a point where they become better representatives of the Company. One of the outstanding avoidable water works losses is the failure to place on the books of the Company all of the money to which the Company is entitled. In every city there are certain people who make an effort to get water without contract or payment, and a real representative of the Company will detect such cases and place that revenue on the books of the Company to the benefit not only of the Company but its other consumers as well. Plumbers have a propensity for connecting supposedly dead service lines and furnishing a portion of the supply for an apparently all-metered building, with a consequent loss of revenue to the Water Department. An efficient water company representative will detect such cases and the Company, or Department, will receive revenue for that service. Meters have a tendency to slow down, and shortly thereafter to cease to operate. A real representative will detect the

slowing down and order the meter out for test and necessary repairs. Service lines have a tendency to waste water and the water company representative should detect that wastage whether it be against the company or against the consumer.

The systematic routing of metered accounts is of special importance in that the elimination of unnecessary steps has a direct bearing upon the morale of the meter readers, or water company representatives. A few months ago the Indianapolis Water Company completed the rerouting of all metered accounts, the rerouting job having taken almost five years. The system is so flexible as to admit of any necessary increase in meter numbers, and no renumbering will be necessary "from now on." Mr. Staley, Chief Clerk of our Company, and Mr. Shively, Chief Meter Reader, estimate that the time saved through the elimination of unnecessary steps is about equal to the time of two meter readers. Under this plan our men pass every Indianapolis property fronting on or in the proximity of water mains, and it is the job of these representatives to see that the Indianapolis Water Company receives from these properties the revenue to which it is entitled.

You will be interested to know that Mr. Shively, our Chief Meter Reader, places the uniforming of meter readers in the front rank of time saving elements and dividend payers. Since these men were placed in uniform it is unnecessary for them to wait for the customer to look them over; size them up and ask them several questions before admitting them to the meter room. The uniform, supplemented by the call "Water Man" is usually answered "Come in," and a material saving in time is effected.

OFFICE EQUIPMENT

Several references are made to the use of machines for mechanical billing, it being the consensus of opinion that an avoidable water works loss can be eliminated through the use of up-to-date mechanical appliances.

We are now using 4 Burroughs Duplex Utility Billing machines, these machines placing on the consumer's bill the following information: Previous meter reading; date of present meter reading; consumption of water; amount of bill; date payable; amount of arrears; total amount due, etc. This information is repeated on the cashier's stub and accounting stub and the information as given on the accounting stub takes the place of the customers' ledger. Each

machine operator prepares from 1,000 to 1,500 completed bills each day.

We now use the new metal F-1 Automatic Addressograph equipped with automatic suction feed and ribbon print, thus eliminating the old and rather messy type of re-inking the ink pads. Several months ago we adopted the post card form of billing and are finding it satisfactory but are unable to say at this time just what the saving has been.

COLLECTIONS

At this time of financial depression, the successful operation of a Department of Collections becomes of vital importance. Messrs. Saville, Gibson and others refer to the importance of prompt collection of all outstanding accounts.

Mr. John A. Bruhn, who has charge of the Division of Collections of our Company, makes the following pertinent comment:

> It is scarcely necessary to mention that of paramount importance is the work all along the line of putting the maximum amount of business on the books. This takes in accuracy of meters, meter reading, billing, adjusting, intense work on increase of business through more fire line installations and decreasing the competition from private sources. After this follows the job of converting as much of this business as is possible into actual cash.

The privately operated plant is not as favorably situated in the matter of collections as is the municipally operated plant where in many cases the water bill is a lien on the property. It is, therefore, highly important that the privately owned company protect itself through deposit, guarantor and prompt collection, otherwise its item of bad debts will reach a point where it places an undue burden upon the other patrons of the Company. In this day of rapid turnover in rentals and property sold on contracts, there will of necessity be many final bills, and it behoves the Water Company or Department to look well to its collections so that its bad debts be not beyond a reasonable amount.

If this paper does nothing more than excite your mild interest, its presentation will have been a failure. If, on the other hand, it stimulates you to make that careful study of your plant which will eliminate many avoidable losses, it will have achieved its purpose and the speaker, together with the men who have assisted in the preparation of the paper, will have been repaid for their efforts.

DISCUSSION

POWER PLANT AND BOILER ROOM LOSSES

H. Rupard:[3] This phase of "Avoidable Water Works Losses" is difficult to treat, because of the large number of different items of equipment and different losses covered by the subject.

The scope of the subject begins with the receipt of the coal or other fuel and carries through the coal handling and storage plant, the boiler plant, the heat balance equipment, the prime movers, the pumps and finally through the piping and valves connecting the pumps to the distribution system.

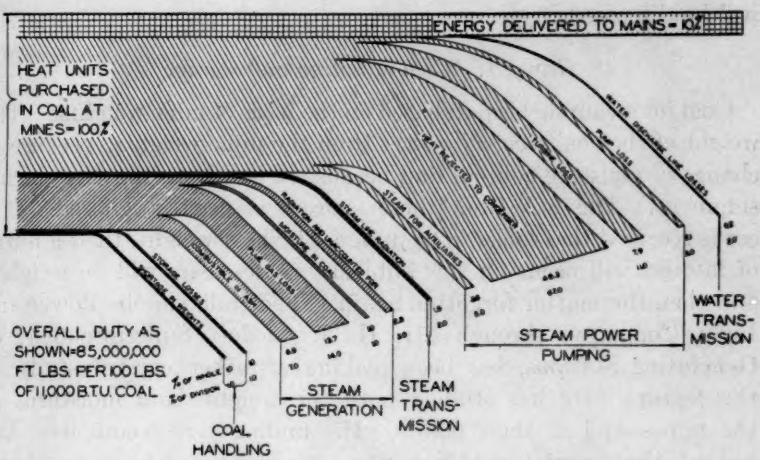

Fig. 2. Power Plant and Boiler Room Losses

Since this field cannot be covered in such a brief time, it will be the intention of this paper to discuss only a few of the major items of heat loss in the process of getting the coal from the mines converted into the power represented by the water output of the pumping station.

Figure 2 has been prepared to show what happens to a heat unit in the coal before it is put in the discharge water as energy. This diagram shows the heat units in the coal as 100 percent and pictures the major items of loss.

[3] Principal Assistant Engineer, Indianapolis Water Company, Indianapolis, Ind.

The information upon which figure 2 is built is not obtained from any one plant. It is a composite of the operating conditions in several plants.

We do not often think of the fact that the energy in the discharge water from a pumping station represents so small a part of the energy purchased in the coal. However, we should not allow this seemingly low efficiency to cause us to lose too much sleep, for this is one of the causes where the engineer is hampered by the laws of nature and by the laws of economics.

This diagram shows that only about 10 percent of the energy available in the coal purchased at the mines is delivered into the mains. The losses are divided into five general classifications and will be discussed by groups.

Group I. Coal handling and storage

Coal for steam fuel is purchased on the basis of mine weights. The weight of the coal received varies from the mine weights, because of change of moisture content and because of loss from the cars during shipment. The loss from these sources is usually ignored. If a car is received that looks to be quite a bit short weight, then a flurry of interest will occur on this subject. A few cars will be weighed and then the matter forgotten again. The Indianapolis Power and Light Company, through Mr. H. J. Sneden, Superintendent of Generating Stations, has been making a rather careful study of this feature. He has studied both the weights and moistures at the mines and at their plants. His findings are incomplete, but indicate that a variation of from 0 to -2 percent may be expected and that this variation is caused chiefly by the varying moisture content. The dry year of 1930 has been reflected in very dry coal at the mines, and the weights of coal received at their plants have checked very closely.

During a year with normal rainfall, or heavy rainfall, when the earth was normally saturated, mine weights would run heavier than delivered weights.

Coal storage at plants sometimes causes appreciable losses. Fires in storage piles are of frequent occurrence and represent definite losses. Coal storage can be carefully handled so that fires will seldom occur. Publications and data are available on this subject and should be studied by every man who is responsible for the creation and maintenance of a coal storage pile.

Group II. Steam generation

Four items of loss in steam generation are shown on figure 2. These are:

1. Combustible in the ash
2. Dry flue gasses
3. Moisture in coal
4. Radiation and unaccounted-for losses

1. Combustible in the ash. The loss caused by unburned carbon in the ash is primarily a function of the design of the installation. Stokers must have sufficient area to maintain a rate of coal burning which will permit a good burn out at the end of the stoker. Air zones and controls must be designed and arranged to supply the proper amount of air for the burn out, without adding too much to the excess air.

This condition was met at the Riverside Station of the Indianapolis Water Company in their most recent installation by the following two points of design in the stoker: (a) 20 percent extra grate area was added by lengthening the standard stoker design; (*b*) six air zones were built in instead of four.

This design allows an excellent burn out at the end of the stoker. At low loads the last two zones are not in use. At high loads the last two zones furnish an excellent opportunity to complete the burn out. Tight air dampers enable the air to be closely regulated to prevent too much excess air. The same result can be reached by other designs. The one thing that must be present in all designs is liberal grate area.

2. Dry flue gas loss. Every pound of flue gases passing through a boiler carries away the quantity of heat necessary to raise the temperature of the flue gas from the room temperature to the stack temperature.

The boilers, economizers and air preheaters are designed to absorb a certain portion of this heat, when a definite quantity of gases are passing through. This design point is based on, say, 13 percent CO_2 in the flue gases. This design point is usually selected at as high a temperature as the construction of the furnace will stand. Increasing the CO_2 in the flue gases means reducing the excess air in the gases, and a rise in furnace temperature results.

This dry flue gas loss is the one most susceptible to control by the operator. Air flow-steam flow meters and CO_2 recorders are the two

means for the control of this item. The air flow-steam flow meter has been widely used to date as a direct means of controlling this loss. The CO_2 meter has been gaining in favor, because it gives a direct reading of an important operating record, instead of a relative one, set by arbitrary calibration, and, because it can be used more accurately over a very wide range of load.

Automatic combustion control is available for all size units and is moderate in price. Properly applied, such equipment will pay for itself quickly.

3. Moisture in coal. Figure 2 shows a very small loss charged against this item. This loss represents the heat necessary to evaporate the water in the coal. This loss is mentioned, because of its important effect on other items, particularly in the control of excess air. To maintain an even and cohesive bed of fuel on a stoker, particularly a chain grate, it is necessary to have sufficient moisture in the coal to prevent the finer particles from burning out too soon and leaving holes in the fine for air to blow through. Automatic devices for wetting coal properly as it is fed to the boilers will make this control simple. The loss caused by the moisture in the coal is more than offset by the gain in heat loss in the dry flue gases.

4. Radiation and unaccounted for losses. When an engineer finishes a boiler efficiency test and has anything that he does not know what to do with, he changes it to Radiators and Unaccounted-for Losses. The amount of heat lost from this source is small, and in a well designed installation, the operator has little or no room for varying the amount of the loss.

At one plant, the operator used his scrap 85 percent magnesia covering to line the walls of the boiler setting outside of the furnace zone. The result was much cooler walls and a very neat appearance of the finished wall.

Group III. Steam transmission

The loss from properly insulated steam mains is small. The merits of insulation are such that they need not be defended here. One feature of the steam transmission system in water works plants that is changing is in the matter of auxiliary steam connections and piping. The habit in the past has been to practically duplicate the main steam piping header system with a smaller system to serve auxiliaries. This auxiliary system consisted of small pipe sizes and screwed joints running at random around the plant, usually in dark

and inaccessible parts of the basement space. The pumping unit being installed now by the Indianapolis Water Company has no source of steam supply except the large main. Two connections are taken off of this main pipe at the closest points for the auxiliary service required. The net result is a decrease of high pressure piping in small sizes, a neater job of piping and equal dependability of operation.

This subject brings up the entire subject of auxiliary piping. Auxiliary piping is too often all a matter of random growth in an older plant. Many operators recognize the bad features of a disjointed and inefficient auxiliary piping system, but cannot get an appropriation to renew the entire layout.

A very good way of improving such a condition is to work out a careful plan of the most efficient layout for the plant needs. Keep this on file, and whenever any repairs, replacements, or additions are necessary, make them in accordance with this predetermined plan. The results will be surprising. In short period of years such a scheme will result in a very orderly and efficient pipe layout.

Group IV. Steam pumping losses

The losses set out under this group are as follows:

1. Auxiliary steam power
2. Heat rejected to condenser
3. Turbine losses
4. Pump losses

The first, third and fourth items of loss are controlled primarily by the design of the unit. So long as the operator maintains the equipment in decent condition, these losses will remain near the design point.

The second loss, that of heat rejected to the condenser is susceptible of some control by the operator; namely, in maintaining as high a vacuum on the turbine at all times as is possible. The operator must watch his operating conditions, and must keep the condenser clean.

Group V. Transmission losses

Certain friction losses are necessary in all piping. Liberal design on piping within a station will keep these losses low. For the planning of new installations, or the improvement of old ones, attention is called to the amount of friction loss through swing check

valves. The saving in power made possible by installing the cone type of check valves will in many cases amount to a large sum in a year.

Duty. The duty represented by figure 2, based on 11,000 B.t.u. coal, is approximately 85,000,000 foot pounds per 100 pounds of coal. The boiler efficiency on the chart is 75 percent. The overall duty of 85,000,000 foot pounds per 100 pounds of coal is a rather good figure for a plant to maintain and could be reached only by a steady load, near the plant rating, and with good equipment.

Instruments and records. In closing this paper, I wish to present a few thoughts on instruments and records as used to check plant operation and efficiency. The value of the indications and records from properly installed and operated instruments does not need to be defended.

However, many plant operators expect an instrument to function properly for an indefinite period with no attention. The best of instruments will not work properly unless they are regularly serviced and checked. The simple bourdon tube pressure gauge, the commonest type of instrument in use is a very inaccurate and undependable instrument if not properly cared for.

The water works operator must recognize the importance of establishing a set and definite routine for servicing and checking all of his instruments. Each instrument should be cleaned and calibrated regularly. The operator can then be assumed that the instrument indications are correct within the range of the accuracy of the instrument, and he can make intelligent steps toward improving the efficiency of his plant by studying each individual loss and reducing it as far as possible.

Records must be continuous and comparative. They must show deviations from set standards. Such deviations must be noted and studied. Constant supervision and watchfulness is necessary.

The answer to such efforts with instruments and records will be in dollars and cents saved from the annual coal bill.

LOSSES IN STEAM DRIVEN PUMPING STATIONS

George T. Gilbert:[4] The major part of the plant here discussed was constructed in 1873. The distribution piping is 4-, 6-, 8- and 10-inch pine wood. The pipe was made from solid pine logs bored to

[4] Superintendent, Water Works, Union City, Ind.

the desired diameter. Each section is 8 feet long and the wall of the pipe is 3 inches thick.

The end of each section was recessed to receive a wood thimble 6 inches long and $1\frac{1}{4}$ inches thick. Wood wedges were used to stop the leaks and a 4-inch draw band was used on each joint.

This pipe has been in service for the past 58 years and the wood is well preserved and smooth inside.

The present water pressure is 52 to 57 pounds per square inch.

During the past week, we have replaced, approximately, 1500 feet of the 10-inch wood pipe with 12-inch cast iron pipe. We still have about 4000 feet of 6- and 8-inch wood pipe in service.

There are many small leaks at the joints of this pipe. Where the streets are paved, the cost of repairing leaks is prohibitive and we are planning to replace this pipe as fast as possible.

Boilers

The pumping-station has 2 Stanwood and Gambel, 66 inches by 16-foot H. R. T. boilers, rated at 100 h.p. Each have 54 4-inch tubes and operate at 115 pounds pressure. The grates are of the shaking type, 5 feet 6 inches wide and 5 feet deep, equaling $27\frac{1}{2}$ square feet.

The chimney is made of radial brick, 90 feet high and 4 feet inside diameter.

The feed piping has been changed from the blow off to the front of the boilers and is located just below the water line and extends to about the center of the boiler. It is provided with a Tee connection that directs the water downward between the tubes.

We are using some boiler compound and have removed about all the old scale.

The boiler tubes are cleaned with a tight fitting hand scraper, three times a day.

Pumps

We have one Laidlow Duplex Pump, size $18\frac{1}{2}$ by 12 by 12 inches. Owing to the high cost of operation, this pump is used in an emergency, only.

One Worthington cross compound non-condensing air compressor, with Myers Valve gear, size 20 by 20 by 13 by 14 inches is used to lift water from 4 deep wells.

The water is delivered to a concrete reservoir that holds, approximately, 300,000 gallons.

One Canton-Hughes cross compound condensing crank and Fly-wheel and Myers Valve gear pump, size $10\frac{1}{2}$ by 18 by $7\frac{1}{2}$ by 12 inches, with a capacity of about 1,000,000 g.p.d. has a surface condensor in the suction pipe. The hot well pump is connected directly to the piston-rod on the house power side.

The vacuum on this pump was 8 to 11 inches, which was due to no packing in the hot well pump, piston and cylinder oil and packing lint in the condensor tubes.

The steam enters the top half of the condensor and the condensate and air go to the condensate pump through the lower half.

The condensor head has two openings, one on the upper side and one on the lower side. It was found that the top steam opening was flush with the condensor shell and the bottom opening was 6 inches above the inside wall of the shell and the tubes on the lower side of the condensor were submerged in oil and water. After the condensor was cleaned, the head was turned over and we are now getting 25 to 27 inches of vacuum.

The pressure in the system is maintained by the constant operation of the Canton-Hughes pump. This pump is connected to the reservoir and also to a dug well.

The dug well produces, approximately, 100 g.p.m. and is pumped directly into the system during the day. At night, the water from this well is enough to maintain the pressure in the system and add some water to the storage reservoir.

Coal

The coal used in 1930 was 4-inch Lump, and owing to the light load on the boilers, could not be burned with a reasonable degree of economy, because of a strong chimney-draft and because the large opening between the lumps of coal caused nearly all the volatile gases to pass out of the stack, due to rapid distillation and excess air which cooled the gases below the temperature at which they would burn. The result of this condition was sooty tubes and a very smoky chimney.

We have gradually reduced the size of coal until we are now burning nut and slack of the proportions 30 to 35 percent nut and 65 to 70 percent dust.

We fire one side of the furnace at a time, with one to two shovels full. The tubes are clean and the chimney will now pass a rigid smoke ordinance.

The coal has a B.t.u. value of about 14,600 and 7 percent ash. It is weighed as fired and each operator has a data sheet, covering the 8 hour run on which he records the weight of coal burned and the gallons of water pumped.

The water pump is calculated from the number of revolutions shown by the counter.

To show the difference in the coal consumed when the boilers were dirty and the pumps in bad repair, we will quote from the the January, 1930, record, shown on the books, which is as follows:

Coal consumed 85 tons or 3 tons per day
Water pumped 11,408,000 gallons per month

From the 1931 record we find:

Coal consumed 43,026 tons or 1.38 tons per day
Water pumped 10,045,800 gallons or 334,050 gallons per day

The 4-inch coal used in 1930 cost $4.60, delivered, and that used in 1931 cost $3.93, delivered.

	dollars
3 tons, per day @$4.60	13.80
1.38 tons, per day @$3.93	5.42
Approximate savings, per day	8.38

The difference in the gallons of water pumped in January, 1930, over the amount pumped in January, 1931, is, no doubt, due to the condition of the pump valves which have been repaired and to the stoppage of a number of bad leaks in the service pipes and mains. A great many steam leaks have also been stopped and the net result is a saving of, approximately, $8.38, per day, in coal.

AVOIDABLE LOSSES IN DISTRIBUTION SYSTEMS

CYRUS A. BIRD:[5] That the subject assigned to me is not a new one is well known. The Romans evidenced their appreciation of the importance of curtailing water waste by conducting investigations on the aqueducts. In recent years much attention has been given to this matter. Messrs. L. R. Howson and W. C. Mabee, individually covered the subject in a most complete and exhaustive manner and presented comprehensive statistics compiled from replies to question-

[5] The Pitometer Company, Detroit, Mich.

naires sent to operators of both municipally owned and privately owned water utilities. Both of these papers were published in the 1928 JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION and were thus made available to those who may not have heard the papers presented. It is not the intention of the writer to discuss the subject in detail, but rather to comment on the various phases of the subject.

The sources of avoidable losses in distribution systems include:

Underground leakage of the mains and services
Willful waste due to defective plumbing
Under-registration of meters
Excessive public uses
Unauthorized uses

In discussing the subject assigned, the speaker is relying to a great extent on experience gained through conducting water waste surveys of both municipal and privately owned water plants.

In all water systems underground leaks develop from time to time. The majority of these soon appear at the surface and are promptly repaired. Those which do not show surface indication, in most cases start with a small flow which finds its way into a sewer. Having once found an outlet, this outlet is enlarged as the leak develops and will doubtless continue for years undetected unless the pavement is so undermined that failure occurs. As an instance of how large such losses may be, the Pitometer Department of the City of Detroit recently located a leak in excess of 3½ million gallons daily, of which there was no surface indication. This was caused by a split 8 feet long in an 8-inch main. Individual leaks of a million gallons per day are not uncommon. To draw conclusions as to what percentage of the consumption is so wasted in the average city is difficult. It varies over a wide range, from 5 to 40 percent and in some isolated instances, as much as 75 percent. The use of the Pitometer is an effective means of discovering excessive underground losses. To explain why there is so wide a variation in this respect is by no means easy. Soil conditions are of course a factor. The care taken to provide even bearing in trenches is insurance against settlement with consequent breaks and leaks at the joints of cast iron mains. The use of lead or copper service pipes minimizes leakage on these connections.

The most effective means of curtailing wilful waste is through the

installation of meters. By this means the running of water to avoid freezing of exposed plumbing during cold weather is eliminated, as well as excessive use of lawn sprinklers during hot weather. Also, as soon as fixture waste is great enough to affect the water bill, the tenant or property owner will have the plumbing put in proper condition. In those cities where local sentiment prevents the universal metering of services, Pitometer measurements combined with house to house inspections and a policy of selective metering has proven beneficial. Buffalo, N. Y., in 1917 was pumping 160,000,000 gallons daily. At that time the city was 7 percent metered. A Pitometer survey was made and the consumption reduced to 120 million. Through the selective metering program adopted together with continued Pitometer measurements and house inspections, the city has prevented an increase in consumption since that time in spite of a material increase in population.

The importance of maintaining meters as nearly as possible to maximum efficiency is a vital one. The interval at which meters should be removed for test varies with local conditions and the types of meters in service. The supplement to the *Manual of Water Works Practice* recommends the following intervals:

SIZE OF METER	INTERVAL BETWEEN TESTS
inches	*years*
$\frac{5}{8}$, $\frac{3}{4}$	5
$1\frac{1}{2}$, 2	4
3	3
4	2
6 and larger	1

Local experience may show that the interval should be shortened or extended.

The most satisfactory tests of large meters are those made in place under actual operating conditions. The use of the Pitometer for such tests has been proven of great value for it is known that the character of the installation will affect the accuracy of certain types of meters. Meters in proper mechanical condition may prove inaccurate if improperly installed.

In discussing meter under-registration, it might be appropriate to give some thought to the matter of determination of meter sizes to be installed on various services. It is well known that the smallest

meter that will satisfactorily deliver the required amount of water will in most cases afford the most accurate registration. More consideration is being given to this matter and many large meters are being replaced by smaller meters with a marked increase in registration. A flagrant example of overmetering recently came to the writer's attention. The case in point was a residential suburb consisting largely of pretentious homes with extensive grounds. Most of these were served with large service connections upon which 4- and in some instances 6-inch disk meters had been installed some years ago. Examination of the records showed that the average daily registration of these meters did not exceed approximately 5000 gallons. It was apparent that the meters were not suited to the services on which they were installed. Smaller meters of the compound type were indicated.

Loss of revenue on metered services is not always due to mechanical defects in the meters. In a city of 70,000 population a change in the form of government took place a year or so ago. The new superintendent was suspicious of the fact that practically all bills sent out were for a minimum amount. When the meters were next read the superintendent withheld the previous readings from the meter readers and as a consequence the new readings bore little relations to the previous figures. It was obvious that no actual readings had been taken for some time, the figures as set down being purely imaginary. The meter readers were discharged. As a result of this change, together with other economies effected in the administration, the water department showed a profit for the past year of $80,000, the first year the department had operated without a deficit.

It is unfortunate that all fixed municipal uses are not metered and charged for even though the municipal departments be given a preferential rate. If such were the case, it would facilitate the elimination of excessive wastes. Intermittent uses such as water used for fighting fires, flushing streets, flushing sewers through fire hose and flushing hydrants may be estimated satisfactorily, but only by metering will the waste in municipal buildings, parks, schools and sewer flush tanks be controlled. Many instances have been encountered where unmetered water supplies to school buildings were allowed to waste through continuously flushing fixtures throughout the summer months when schools were not in session. Sewer flush tanks, if neglected, will far exceed the usual 500 gallons per day, in some instances running as much as 25,000 gallons a day.

Unauthorized use of water may occur through services of long standing which were never recorded; or by the consumer making a connection on a line installed for fire protection; or by by-passing a meter. Where it is evident that the unauthorized use is deliberate, it is almost invariably the case that it is without the knowledge of the officials of the company involved, but rather the act of a department head thinking to make a favorable showing in his department by reducing costs. Individual cases of unauthorized use have been discovered involving millions of gallons of water per day. In one instance, it was shown that a large industrial plant was obtaining in excess of 3 million gallons per day by by-passing a 10-inch meter. The city brought suit for the back water bill. The case was carried to the state Supreme Court where a Judgment of $389,000 was given the city.

The percentage of the total consumption which it is possible to account for by consumers' meters will usually be larger in those cities where the industrial use is great. To illustrate by example: Consider a city which is 100 percent metered. Assume a daily consumption of 3,000,000 gallons, 2,000,000 of which $66\frac{2}{3}$ percent is accounted for by the consumers' meters. Suppose a new industry taking 1,000,000 gallons per day, were added to the list of water users. The total consumption is now 4,000,000 and the accounted for 3,000,000 or 75 percent. The percentage has increased automatically without effort by the local department.

Mr. Biggs, Chief Engineer of the American Water Works and Electric Company, operators of numerous water plants throughout the country, stated that in one of their plants serving industrial consumers almost exclusively, the accounted for water is 97.5 percent.

It is believed that it is possible to bring the accounted for water to 85 percent if modern methods are employed and in many instances to exceed that figure.

SERVICE PIPES OF VARIOUS MATERIALS[1]

By R. W. Reynolds[2]

Prior to 1926 all services on the system of the West Palm Beach Water Company were of galvanized iron pipe. Some of the earlier ones were installed with lead goose-necks, but this practice was discontinued because of the softness of the water. The discontinuance of the lead goose-neck left us with a more or less rigid connection, which, of course, is undesirable. Furthermore, the water supplied is very soft and at times has been very corrosive, with the result that in 1926 serious trouble began to develop in the form of red water and low pressure complaints, most of which were the result of badly corroded services. As a result we adopted cement lined galvanized pipe as our standard service pipe material. This practice apparently has solved the problem insofar as corrosion is concerned, but we were left with the rigid connection. We were also impressed with the fact that the practice necessitated in some cases the use of oversized pipe, which considerably increased the cost.

About two years ago it was decided to use copper tubing in an experimental way for services. A limited number of services were so installed, with such encouraging results, that during the following year nothing but copper tubing was used for this purpose. We are convinced that these services will show lower maintenance charges in years to come, and that their first cost will average slightly less than the cost of cement lined services of equivalent capacity. As a result of our experience during 1929 we have now adopted the use of copper tubing as standard practice, and we have thus been led to further investigation to develop its use to the best advantage.

LOSS OF HEAD IN SERVICES

One of the problems confronting the men in the field was the determination of the proper size of pipe to use. To settle this point a

[1] Presented before the St. Louis Convention, June 6, 1930.

[2] Superintendent, West Palm Beach Water Company, West Palm Beach, Fla.

TABLE 1

Friction loss in service pipes

Test pieces 19 feet long

TEST PIECE	FLOW		STATIC PRESSURE, POUNDS	WORKING PRESSURE, POUNDS		MANOMETER INCHES OF MERCURY			LOSS OF HEAD, FEET $H_7 = 1.048$ h	LOSS OF HEAD PER 10 FEET OF PIPE	
	Cubic feet per meter	Gallons per meter		1	2	A	B	Diff. = h		Feet	Pounds
1¼ inch galvanized cement lined	6.60	49.50	41.5	35.0	26.0	1.35	22.65	21.30	22.32	11.75	5.47
	5.20	39.00	41.5	37.5	32.0	5.50	18.50	13.00	13.62	7.17	3.34
	3.40	25.75	41.5	39.5	36.5	8.80	15.20	6.40	6.71	3.53	1.94
	2.00	15.00	41.5	40.0	39.0	10.90	13.10	2.20	2.31	1.22	0.57
	1.40	10.50	41.5	40.5	40.0	11.50	12.50	1.00	1.05	0.55	0.25
1¼ inch galvanized unlined	12.50	93.75	41.5	22.0	13.0	1.80	22.20	20.40	21.38	11.25	4.99
	9.80	73.50	41.5	29.5	24.0	5.90	18.10	12.20	12.79	6.73	3.10
	7.70	57.75	41.5	36.5	34.0	8.30	15.70	7.40	7.76	4.08	1.90
	3.90	29.30	41.5	40.0	39.0	11.00	13.00	2.00	2.10	1.11	0.59
	2.60	19.50	41.5	41.0	40.5	11.50	12.50	1.00	1.05	0.55	0.25
1¼ inch copper	11.50	36.30	39.0	21.0	11.5	1.40	22.60	21.20	22.22	11.69	5.44
	9.00	67.50	39.0	27.7	21.7	5.15	18.85	13.70	14.36	7.56	3.53
	6.25	46.87	39.0	33.5	30.5	8.45	15.55	7.10	7.44	3.92	1.82
	3.50	26.25	39.0	37.0	35.7	10.75	13.25	2.50	2.62	1.38	0.64
	2.12	15.90	39.0	38.0	37.7	11.45	12.55	1.10	1.15	0.61	0.28
1¼ inch galvaaized unlined corroded	2.20	16.50	46.0	44.5	36.0	1.70	22.30	20.60	21.59	11.36	5.29
	1.60	12.00	46.0	45.0	39.5	5.80	18.20	12.40	13.00	6.84	3.19
	1.10	8.25	46.0	45.5	44.0	9.50	14.50	5.00	5.24	2.76	1.29
	0.75	5.63	46.0	46.0	45.5	11.15	12.85	1.70	1.78	0.94	0.43
1 inch galvanized unlined	6.90	51.80	48.5	39.0	24.0	1.00	23.00	22.00	23.06	12.14	5.63
	5.10	38.30	48.5	43.0	37.5	5.80	18.20	12.40	13.00	6.84	3.19
	3.20	24.00	48.5	47.0	45.0	9.40	14.60	5.20	5.45	2.87	1.33
	2.00	15.00	48.5	48.0	47.5	10.85	13.15	2.30	2.41	1.27	0.59
	1.30	9.75	48.5	48.5	48.0	11.50	12.50	1.00	1.05	0.55	0.25
1 inch galvanized cement line	3.70	27.75	41.5	38.5	28.5	0.85	23.15	22.30	23.37	12.30	5.73
	2.90	21.75	41.5	39.5	33.5	4.90	19.10	14.20	14.88	7.83	3.65
	1.90	14.25	41.5	40.5	37.5	8.45	15.55	7.10	7.44	3.92	1.82
	1.20	9.00	41.5	41.0	40.0	10.60	13.40	2.80	2.93	1.54	0.72
	0.80	6.00	41.5	41.5	41.5	11.50	12.50	1.00	1.05	0.55	0.25

TABLE 1—*Continued*

TEST PIECE	FLOW: Cubic feet per meter	FLOW: Gallons per meter	STATIC PRESSURE, POUNDS	WORKING PRESSURE, POUNDS: 1	WORKING PRESSURE, POUNDS: 2	MANOMETER INCHES OF MERCURY: A	MANOMETER INCHES OF MERCURY: B	MANOMETER INCHES OF MERCURY: Diff. = h	LOSS OF HEAD, FEET $H_7 = 1.048\ h$	LOSS OF HEAD PER 10 FEET OF PIPE: Feet	LOSS OF HEAD PER 10 FEET OF PIPE: Pounds
1 inch copper	6.50	48.70	38.0	28.7	19.7	1.45	22.55	21.10	22.11	11.64	5.42
	5.30	39.75	38.0	31.5	25.5	4.70	19.30	14.60	15.30	8.05	3.75
	3.80	28.50	37.0	34.5	31.5	7.90	16.10	8.20	8.59	4.52	2.11
	2.10	15.75	37.0	36.0	35.0	10.65	13.35	2.70	2.83	1.49	0.69
	1.00	7.50	37.0	36.5	35.7	11.55	12.45	0.90	0.94	0.49	0.23
1 inch galvanized unlined corroded	2.10	15.75	47.5	46.5	36.5	0.60	23.40	22.80	23.89	12.57	5.85
	1.90	14.25	47.5	46.5	40.0	5.00	19.00	14.00	14.67	7.72	3.60
	1.10	8.25	47.5	47.0	45.0	9.40	14.60	5.20	5.45	2.87	1.33
	0.60	4.50	47.5	47.5	47.0	11.25	12.75	1.50	1.57	0.83	0.38
2 inch galvanized unlined	17.00	12.75	41.5	6.5	4.0	8.7	15.3	6.60	6.92	3.64	1.67
	14.60	109.5	41.5	17.0	15.0	9.65	14.35	4.70	4.93	2.59	1.20
	10.80	81.0	41.5	28.0	27.0	10.70	13.30	2.60	2.72	1.43	0.67
	7.00	52.5	41.5	36.0	35.5	11.50	12.50	1.00	1.05	0.55	0.25
2 inch galvanized cement lined	17.00	127.5	41.5	7.5	4.5	8.00	16.00	8.00	8.34	4.39	2.05
	15.00	112.5	41.5	16.5	14.0	9.10	14.90	5.80	6.08	3.20	1.49
	8.50	63.7	41.5	33.5	32.5	11.00	13.00	2.00	2.10	1.11	0.52
	6.00	45.0	41.5	38.0	37.5	11.50	12.50	1.00	1.08	0.55	0.25
2 inch copper	18.00	135.0	41.5	6.7	5.0	9.25	14.75	5.50	5.76	3.03	1.41
	14.00	105.0	42.0	20.5	19.5	10.25	13.75	3.50	3.67	1.93	0.90
	9.00	67.5	42.0	32.5	32.2	11.25	12.75	1.50	1.57	0.83	0.38
	4.00	30.0	42.0	40.0	39.7	11.85	12.15	0.30	0.31	0.16	0.08
2 inch galvanized unlined corroded	7.80	58.50	39.5	32.0	22.0	0.60	23.40	22.80	23.89	12.57	5.85
	6.20	46.50	39.5	35.0	28.5	4.80	19.20	14.40	15.09	7.94	3.51
	4.20	31.50	39.5	38.0	35.0	8.75	15.25	6.50	6.81	3.58	1.67
	1.90	14.25	39.5	39.5	38.5	11.30	12.70	1.40	1.47	0.77	0.36
1½ inch galvanized unlined	16.00	12.00	41.5	12.0	5.0	3.90	20.10	16.20	16.98	8.94	4.15
	12.80	96.0	41.5	21.0	10.0	6.25	17.75	11.50	12.05	6.34	2.96
	9.50	71.3	41.5	31.0	28.5	9.00	15.00	6.00	6.29	3.31	1.54
	5.40	40.5	41.5	38.5	37.5	11.00	13.00	2.00	2.10	1.11	0.52
1½ inch galvanized cement lined	12.30	92.3	41.5	21.5	11.5	1.25	22.75	21.50	22.53	11.86	5.55
	9.20	69.0	41.5	29.5	24.5	5.80	18.20	12.40	13.00	6.84	3.20
	6.80	51.0	41.5	36.0	33.0	8.80	15.20	6.40	6.71	3.53	1.64
	3.90	29.2	41.5	40.0	39.0	11.00	13.00	2.00	2.10	1.11	0.52
	2.50	18.7	41.5	40.5	40.0	11.50	12.50	1.00	1.05	0.55	0.25

TABLE 1—*Concluded*

TEST PIECE	FLOW		STATIC PRESSURE, POUNDS	WORKING PRESSURE, POUNDS		MANOMETER INCHES OF MERCURY			LOSS OF HEAD, FEET $H_7 = 1.048$ h	LOSS OF HEAD PER 10 FEET OF PIPE	
	Cubic feet per meter	Gallons per meter		1	2	A	B	Diff. = h		Feet	Pounds
1½ inch copper	16.25	122.0	43.5	11.1	1.0	2.80	21.20	18.40	19.28	10.15	4.73
	14.25	107.0	44.0	19.0	12.5	5.10	18.90	13.80	14.46	7.61	3.54
	10.25	76.9	44.0	31.0	27.7	8.35	15.65	7.30	7.65	4.03	1.88
	7.50	56.3	44.0	38.0	36.0	10.10	13.90	3.80	3.98	2.10	0.98
	5.00	37.5	44.0	41.0	40.2	11.00	13.00	2.00	2.10	1.11	0.52
	3.30	24.7	44.0	42.0	42.0	11.55	12.45	0.90	0.94	0.49	0.23
1½ inch galvanized unlined corroded	3.90	29.25	46.0	44.5	35.5	1.90	22.10	20.20	21.17	11.14	5.18
	2.85	21.40	46.0	45.0	39.5	5.85	18.15	12.30	12.89	6.78	3.15
	2.10	15.70	46.0	46.0	43.0	8.90	15.10	6.20	6.50	3.42	1.59
	1.00	7.50	46.0	45.5	45.0	11.20	12.80	1.60	1.68	0.88	0.41
¾ inch galvanized unlined	3.70	27.80	40.5	36.5	25.7	0.10	23.90	23.80	24.94	13.13	6.11
	2.80	21.00	41.0	38.0	32.0	4.90	19.10	14.20	14.88	7.83	3.64
	1.90	14.30	41.0	39.5	36.5	3.55	15.45	6.90	7.23	3.81	1.77
	1.20	9.00	41.0	40.0	39.0	10.65	13.35	2.70	2.83	1.49	0.69
	0.60	4.50	41.0	40.2	40.0	11.45	12.55	1.10	1.15	0.61	0.28
¾ inch copper	3.00	22.50	37.0	31.5	22.0	0.80	23.20	22.40	23.48	12.36	5.75
	2.25	16.90	37.0	33.0	27.0	4.80	19.20	14.40	15.09	7.94	3.70
	1.70	12.75	36.5	35.0	32.0	8:00	16.00	8.00	8.38	4.41	2.06
	0.80	6.00	36.5	36.0	35.0	10.90	13.10	2.20	2.31	1.22	0.57
	0.50	3.75	36.5	36.2	36.0	11.55	12.45	0.90	0.94	0.49	0.23
¾ inch unlined corroded	2.20	16.50	48.0	45.5	35.5	0.35	23.65	23.30	24.42	12.85	5.98
	1.50	11.25	48.0	47.0	41.5	5.90	18.10	12.20	12.79	6.73	3.11
	1.15	8.63	48.0	47.5	45.5	9.50	14.50	5.00	5.24	2.76	1.28
	0.60	4.50	48.0	48.0	47.5	11.20	12.80	1.60	1.68	0.88	0.41

series of tests was run to measure the friction losses in copper tubing, unlined iron pipe, and cement lined pipe. The results of these tests are shown on figure 1 and in table 1.

Tests were also run on used unlined iron pipe, with rather startling results. All of the used samples were in what might be called a fair condition, and the great loss in carrying capacity was surprising to the writer. Inasmuch as unlined iron pipe must be sized to discount this loss of capacity it is obvious that in most cases copper tubing need not be as large as the corresponding iron pipe.

Referring to figure 1, it is evident that usually 1½-inch copper tubing will be quite as satisfactory after a few years as 2-inch unlined iron pipe.

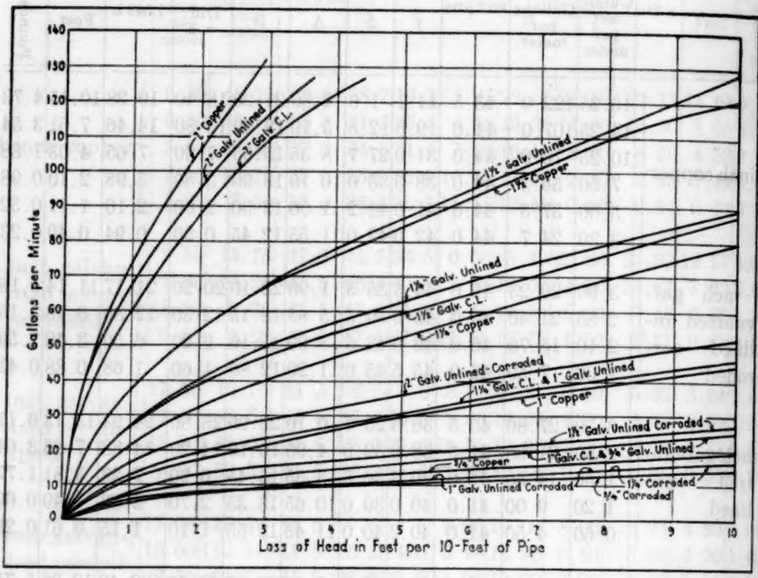

FIG. 1

TABLE 2

Diameters of service pipes

NOMINAL DIAMETER, INCHES	ACTUAL DIAMETER, INCHES	
	Iron	Cooper
¾	0.824	0.745
1	1.048	0.995
1¼	1.380	1.245
1½	1.611	1.481
2	2.000	1.959

Test samples were prepared from 20-foot lengths of pipe. Quarter inch brass nipples were brazed into the sides of these samples, exactly 19 feet apart, and connected by means of copper tubing to a differential mercury manometer. The flow of water was controlled at the

outlet-end of the pipe and measured by means of a 1½-inch disc meter. Tests were run at four or more velocities for each sample.

The results were gratifyingly consistent, so that we are inclined to have great confidence in them. It will be noticed that all the points plot on a very smooth curve.

In all cases copper tubing shows a decidedly more favorable value for "C." This fact is not readily apparent from the curves because in most cases iron pipe runs considerably larger than the nominal diameters, whereas the copper tubing runs slightly smaller, as indicated by the data in table 2.

The data in table 2 are taken from pipe tables, but in the case of the 1-inch pipe a check was made by weighing the water in a length of pipe. By this method it was also determined that the thickness of cement lining was "0.058."

It is interesting to note that the points for ¾-, 1-, and 1¼-inch used iron pipe fall on practically the same curve, due undoubtedly to the fact that the samples were not of the same age.

The writer wishes to acknowledge the assistance of J. R. Tanner, Assistant Superintendent of the West Palm Beach Water Company, under whose direction this series of tests was conducted.

DISCUSSION

J. E. Gibson:[3] The service pipe is a very important link in the water works plant, as by this link the water plant is enabled to deliver water to its consumers and receive revenue therefor. So the class of material, friction losses, and maintenance of the service pipe are important items to the water works plant.

No hard and fast rules can be determined as to the nature of the material to be used, for it would be idle and a waste of time to recommend that one class of material to the exclusion of all others be adopted universally throughout the country. The character of the water, character of the soil, experience in each locality as to the best results to be obtained with the various materials should govern in any particular locality. It can be answered as a well-known engineer answered a question put to him as to what was the best kind of pipe smoking tobacco. His reply was "The kind that you are using." And in many cases this is the kind of service pipe that the superintendent should use in his work; or, to put it in other words,

[3] Manager and Engineer, Water Department, Charleston, S. C.

the superintendent should experiment with the various materials only until he has determined the best material for this particular situation and water, and, after having done this, adopt that material as his standard for that locality.

We use AA lead pipe for all services from ¾- to 2-inch in diameter. However, we became interested in flexible copper tubing and in the red brass of iron pipe size manufactured by the Anaconda Company and known as their No. 85 red and No. 67 yellow. Before making any changes in our practice we thought it advisable to determine the friction losses on the different classes of material, and accordingly we made some very exhaustive tests covering ¾- and 1-inch size piping, including copper tubing, AA lead, No. 85 red brass iron pipe size, standard galvanized steel and cement-lined steel pipe. It was recognized at the beginning that standard galvanized iron or steel pipe would not be satisfactory on account of soil corrosion, but we conducted these tests simply to obtain comparable information. The results of most of these tests were given in a paper in Water Works Engineering issue of July 19, 1929. Our tests covered the entire service pipe and included the corporation cock, 25 feet of service pipe in the street, curb cock, meter located at the curb line, and 10 feet of service pipe across the sidewalk, or a total of 35 feet from main to property line. This length was adopted on the premise that the average service pipe was approximately this length and that the friction losses in this length of service pipe would be readily comparable and useful to superintendents throughout the eastern United States. If the length of service pipe were less than this, it would simply result in the consumer getting a little bit better pressure. The results were given in tabular form in gallons per minute flow so that it would not be necessary for the superintendent to make a combination of different length pipes, with different corporation cocks, meters, etc. The tabulation showed the percentage of loss on each of the units making up the total installation. The tests were made directly under the charge of F. B. McDowell, my assistant.

From these experiments we determined and plotted curves showing the loss of head in 100 feet of pipe of the various sizes and material. From these graphs it may be noted that ¾-inch lead pipe has a slightly better carrying capacity, with the same loss of head, than the copper flexible tubing. In both cases these pipes had a neat internal diameter of ¾-inch. You will note further that the ¾-inch galvanized pipe has a much better carrying capacity than either the lead or cop-

per tubing and this is explained by the fact that the nominal $\frac{3}{4}$-inch galvanized pipe has an actual diameter of 0.824 or approximately $\frac{13}{16}$-inch, and this dimension applies also to the iron pipe size brass pipe. The same condition holds true for the 1-inch galvanized pipe. The lead pipe shows in all cases better carrying capacity than the copper tubing, and the iron size brass pipe better than either of the other two, which, as noted above, is due to the actual diameter being larger than the nominal diameter. It will be noted that the cement-lined pipe shows a carrying capacity different from any of the others. This is due to the fact that 1-inch and $1\frac{1}{4}$-inch steel pipe lined with cement, which reduces the diameter somewhat in each case, is larger than the standard $\frac{3}{4}$-inch and 1-inch pipe. I think the general impression is that copper tubing has a better carrying capacity than lead pipe, but none of our tests gave this result. The explanation is that the lead pipe soon acquires a slick, greasy coat on the interior surface, materially reducing the friction losses; whereas the copper pipe does not seem to have this attribute.

In studying the friction losses in 35 feet of $\frac{3}{4}$-inch lead service pipe in percentages of the total loss of each of the units making up the service line, it is noted that the loss of head in the meter is a very material proportion of the total loss. My object in presenting this is to show the objection to using a reducing size meter in the service line. In using a $\frac{5}{8}$-inch meter with a $\frac{3}{4}$-inch spud, the friction loss of the meter is practically equal to that of 25 feet of service pipe in the street. In cities where moderate pressure is maintained—40 to 50 pounds—this friction loss in the meter is of material moment, and the practice of using a meter smaller than the service pipe should not be followed except in the bungalow type of house where water is drawn only on the first floor.

The greatest objection to lead pipe and copper tubing is in the danger of it becoming flattened or being easily injured by other workmen digging in the street. We all realize that if either pipe becomes flattened the area is reduced without changing the wetted perimeter, reducing the hydraulic radius, increasing the friction, and reducing the quantity or flow of water. Iron pipe size brass pipe overcomes these objections in that it is more resistant to external abuse or deformation.

Lead and flexible copper tubing permit of the service pipe freezing without rupture. This has some advantages, particularly in climates where only during abnormal years do you have frost penetrating

sufficiently to freeze the service pipe at normal depth, and, therefore, it is not necessary to lay the service pipes to the depth required to meet the occasional extreme winters.

It is often necessary to replace curb cocks due to accidents and careless handling, and in this day of modern patented pavement, it is quite common practice to undermine the pavement near the curb and freeze the service pipe back of the curb cock and replace the defective cock without opening up the street paving. Lead and flexible copper tubing have advantages over the galvanized iron or iron pipe size brass pipe when this class of work is attempted, as they are not so likely to split or burst due to the greater ductility of the metal. This method of replacing defective curb cocks is a kink that is worth knowing and saves many dollars in the maintenance of services, and reduces criticism from having to cut up the paving.

Stephen H. Taylor:[4] Mr. Reynolds has given us a very interesting paper on "Service Pipes" and it is the result of very careful tests.

It becomes more and more evident that the service pipe question is very largely a local one, depending upon the chemical composition of the water being delivered and the ground in which the pipes are buried. The pipe that would best suit conditions in one location might be entirely wrong for another. For instance, in New Bedford when the works were built some sixty years ago some service pipes were put in with wrought iron and some with lead. After a few years the wrought iron services filled up with rust and tubercles, so that they were practically useless and had to be replaced. On the other hand, the lead pipes put in sixty years ago are still giving good service with no trouble from lead poisoning. As a consequence of this experience lead pipe was adopted as standard many years ago, and has been the standard ever since.

A neighboring town which takes water from New Bedford laid its original services some fifteen years ago with lead lined iron pipe, but because of failures, most at the joints, many of these have had to be removed and they are now using copper tubing with results which are satisfactory to them up to date.

Other communities will find it impossible to use lead pipe, as the chemical contents of the water are such that lead poisoning would result.

[4] Superintendent, Water Department, New Bedford, Mass.

As far as the cost of the various materials is concerned the cheapest pipe to install might be the most expensive in the long run. It certainly was so in our case when the wrought iron pipe had to be removed and replaced after a few years; whereas, the original lead pipe services are still in use.

The writer has been urged by representatives of the copper tubing manufacturers to adopt this material instead of lead. As near as I can figure there is very little difference in the cost of installation of the two materials. Having had a very favorable experience with lead pipe, one hesitates to change unless a considerable advantage can be shown as a result of making any change. The difference in the cost between the highest and lowest price of material is neglible when compared with the cost and inconvenience to the public of tearing up one of the expensively paved streets because the material has proved defective. The labor cost of installing either inferior or superior material is about the same, consequently I believe we should forget the original cost in installing our services and try to get the material that is best suited for local conditions. Before any material is adopted by any community, a careful analysis of the chemical contents of the water and ground should be made, and the pipe best suited to meet these conditions should be adopted regardless of the first cost.

Mr. Reynolds' experiments have shown that the non-ferrous metals retain their carrying capacity long after the capacity of the iron pipes had been greatly reduced. The same thing will probably be true of all the soft waters. For this reason the money invested in a pipe which will not fill up is well spent and will result in a saving in the long run.

In communities where lead pipe cannot be used because of the danger of lead poisoning, undoubtedly, copper tubing, copper, brass, or cement lined pipe should be used, unless the conditions are such that wrought iron pipe will not fill and corrode.

WILLIAM LUSCOMBE:[5] We use lead pipe exclusively for the smaller service pipe lines. We have an average of about fifty-five pounds pressure. We use the $\frac{5}{8}$-inch extra strong lead for the ordinary residence, and the $\frac{5}{8}$-inch size meter also in such an installation. Mr. Gibson remarked about not using a smaller meter than three-quar-

[5] Vice-president, Gary Heat, Light and Water Company, Gary, Ind.

ters, in such installations where you had forty-five or fifty pounds pressure. We buy the meters, furnish them to the customers, and according to the experience we have had, covering about twenty odd years without having had a complaint about an insufficient supply, I do not believe the utility company would be justified in making the additional investment in the larger sized meter. There is quite a difference in price between the $\frac{5}{8}$ and $\frac{3}{4}$ size. If the customer is satisfied, I question the advisability of putting that additional money in the form of larger sized meters.

JAMES E. GIBSON:[2] We have a very tuberculating water, and repeatedly in the last three or four years, we have had complaints of low pressure. When we get these complaints, the first thing we do is to disconnect the service at the meter, which is at the curb, and make a test flow to see what quantity of water is delivered and what the loss of pressure is, using a record either by gauge on the nearest hydrant or by comparing with the gauge in our office, and the time. Wherever we find that we are not getting what we consider a normal flow, we get a permit from the street department to open the street at the curb, at the corporation cock and examine it. In the older services, we found almost universally that the corporation cock did not go through the cast iron pipe, but was screwed in possibly $\frac{2}{3}$ to $\frac{3}{4}$ thickness of the wall of the pipe, and the tuberculation had grown around the ring of the pipe opening until it was entirely closed up.

For a long time we would simply insert a drill and drill out that corroded material, but to our surprise it soon re-formed. In the course of another eight or ten months a complaint would be received from the consumer again that he had no pressure. Of course, you must remember that the consumer thinks of pressure and not volume. It is volume that he wants, but he thinks it is pressure. So we have adopted a corporation cock that looks very much like the older cock before filtration of water supply was adopted, when we had eels, fish and other things in our water supply, and with that eel guard on it. Instead of having the slotted area, we simply cut the end of the corporation cock off, and we have a plain piece of pipe inserted into the main probably $\frac{1}{4}$ to $\frac{3}{8}$ of an inch, and wherever we have done that, we have stopped tuberculation going over in the end of the pipe and stopping the water.

Whenever we get a complaint now on our old system, where we

have no cement lined pipe, and we find the delivery is up to us, we simply plug the old tap and make the new corporation cock with this extension on the inlet end.

A great many times we find the trouble is not up to us. We find the plumber has guaranteed to put in $\frac{3}{4}$-inch pipe and played upon the frugality of the house owner and put in $\frac{1}{2}$-inch pipe, because that measures pretty near $\frac{3}{4}$ of an inch outside. That is the way he gets away with it, and the way the Department gets the blame.

With reference to the $\frac{5}{8}$ meter, from my experience at Charleston, I have come to the conclusion that the consumer is entitled to a full size opening from the main to his property line, and if he wants to cut it down to $\frac{5}{8}$, or any other size, that is his doing and not the water department's.

W. C. Hawley:[6] It seems to me we make trouble for ourselves by designating our meters by the size of the spuds or connection instead of by the capacity of the meters. Fortunately, in my own case a large part of our distribution system is supplying under pressures of 125 to maximum of 225 pounds. We can put a $\frac{5}{8}$-inch meter on a $\frac{3}{4}$-inch pipe and there is no trouble. When we get up on the hills where the pressure is less, then we have to go to the larger meters. After all, it is a question of the demand that is going to be made, and that is going to vary with the number of fixtures and the pressure. If we could get away from the designation of the meter itself as $\frac{5}{8}$ and $\frac{3}{4}$, and instead of saying that, say a meter of so many gallons capacity, we would save a lot of argument with our customers.

J. E. Gibson:[3] My experience in copper pipe is gained entirely on a limited period of time at Charleston, and there we have had no encrustation. The copper pipe seems to stay just as clean after two years as it was when we put it in.

In our lead pipe, we get a smooth, slimy surface. When you rub it with your hand you get a little coating off, probably a hundredth of an inch thick, and that explains somewhat, I think, our better carrying capacity on lead over the copper tubing.

Samuel B. Morris:[7] I would like to ask Mr. Gibson whether they have had experience in the use of water for refrigerator appliances.

[6] Chief Engineer and General Superintendent, Pennsylvania Water Company, Wilkinsburg, Pa.

[7] Chief Engineer, Water Department, Pasadena, Calif.

In Pasadena we have quite a large use of the household refrigerator, some of which are water cooled. The gas operated ones are all water cooled and require, on the average, a stream of four or five gallons an hour to take care of the cooling. If you have meters larger than the minimum requirement, it is difficult to measure such low flows, and it occurs to me that in Mr. Gibson's case a $\frac{3}{4}$-inch meter might have a little more difficulty in registering streams as low as that in comparison to the duty performed by a $\frac{5}{8}$-meter.

James E. Gibson:[3] Up until within the past year, our utility was owned jointly, that is, both the gas and electric companies were one and the same company. The electric company pushed the electric refrigerator and forgot about the gas refrigerator. So we have few of the gas type. The gas company now has been taken over by the gas utility and divorced, at least as far as incorporation in the state is concerned, from the electric company. One reason I think the gas type has been unpopular with us,—is that our gas rate is high, $1.55 a cubic foot; the electric rate has been high, but they give a special rate if you put in a refrigerator. Many people have put in refrigerators and are now running their refrigerator and light load at the reduced rate more cheaply than they were running their light load before. In addition, our water in the summer gets rather warm. Water leaving our plant will reach, in July, August and September, about 75°F. Of course, it is chilled a little bit before it gets down town through the distribution system, but it is warm.

Samuel B. Morris:[7] In Pasadena we are interested in conservation of water. We prohibited the use of water for cooling purposes unless it is recirculated, and we have some complaints from the gas operated refrigerator manufacturers that we were excluding them. That criticism was probably earned a little further by the fact that we furnish both water and power and do not furnish gas, but we adopted that ordinance so as to avoid the large waste of water which occurs from the general use of the gas machines. A use of about five gallons an hour in the average home represents an increase of about twenty-five percent in the normal use of water. If these gas operated machines were adopted by anything like the same percentage of people as have been using the electrically operated machines, it would cause a material increase in our water demand.

MR. NELSON (New York City): We had occasion in New York City recently to answer some inquiries regarding the amount of water used by the gas refrigerators. We have a fixed charge of $2.50 a year for the ordinary type of gas refrigerator. We recently made some tests of some 300 of those refrigerators to find out whether our charge was proper or not. We found that the gas refrigerators, if they are properly adjusted, will use a quantity of water that would be within that charge. In other words, in New York City, $2.50 would represent 2,500 cubic feet. But most of the refrigerators were not kept in that adjustment. Some of them we found using as high as 12,000 cubic feet per year. Others were coming a little bit below the 2,500 cubic feet a year, and that quantity may vary with the weather temperatures, of course, and more closely with the room temperatures. Considerably more water is used in a warm climate where the temperature of the water is higher.

T. J. SKINKER:[8] We have had the same question as to our charge on a gas refrigerator. We are charging $10.00 a year for gas refrigerators, and the gas company here has been kicking about it. We have run tests and we find that they use about $7.50 to $11.00 worth of water. Our maximum rate is fifteen cents per 100 cubic feet. In July and August, the temperature of our water gets as high as 81° and 82°F. There has been some question in my mind in making the charge on the gas refrigerators whether we should use our maximum rate. Frankly, I feel that we ought to make some concession there because they are using more water and we should not charge the maximum rate.

SAMUEL B. MORRIS:[7] The matter of measuring small flows of water in ordinary domestic meters is not so simple as it appears on a test bench. When the City of Pasadena first purchased its water system from private companies in 1912, my predecessor, who was then Chief Engineer, wanted to conserve the water of the city and he put a little demonstration in the window of the office, in which he had a dripping hydrant and a meter to register the amount of water which went through and the amount of money which would be represented in that loss for a period of a month and a year. The water was started up and allowed to drop, and the meter did not register. We

[8] Engineer in charge of distribution, Water Department, St. Louis, Mo.

sent back to the manufacturer for the best meter they could get, toned up so it would register, and we could not get a meter to register that did not have a pretty sizable leak which the average person could not permit in a hydrant. Large leaks do occur in other fixtures than the kitchen sink fixtures, but we had another interesting thing in that connection.

T. J. Skinker:[8] In connection with this gas refrigerator, we ran some tests trying to find a meter that would register the amount of water that is necessary to cool a seven cubic foot gas refrigerator. I think we tried about a half dozen different makes. We tried one make, a $\frac{3}{8}$-inch meter they were sure would register the quantity of water passing through this refrigerator. I do not remember the exact figures, but I think the best that any meter did was about seventy some odd percent of the water that was used, and some of them ran down 10 or 12 percent.

CAST IRON PIPE 260 YEARS OLD IN FRANCE[1]

By Burt B. Hodgman[2]

"What is the life of cast iron pipe?" This question has often been asked and answered in widely varying ways. The writer has answered this question by saying, "five hundred years or more." Nobody has yet determined.

Because of the value of the answer to this question, the writer was very much interested in visiting Versailles, France, and inspecting the oldest cast iron pipe known. This pipe was laid by Louis XIV, that able monarch, who said "L'Etat c'est moi" — (I am the State).

When Louis Quatorze built the Versailles Palace and gardens, he wanted fountains to entertain and please his wives and sweethearts, so he called in the best engineers of his time, ordering them to build and they built so well that the plant still operates today some two hundred and sixty years later.

The plant, as originally built, consisted of a pumping station at Marly on the Seine River, about nine kilometers from Versailles, a cast iron pipe line from there to Versailles and, from this main line, branch lines leading to the fountains. All of this construction was done between 1664 and 1685.

To get permission to inspect these works was a problem. The writer was told it would be impossible if he was to be in France only a week or ten days, but, still hoping, he applied to Sidney R. Clarke, ex-secretary of the Advertising Club of New York, now president of the International Service Company, in 76 Rue des Petits Champs, Paris, where he does things. When our wishes were made known to him things began to move. A letter was dispatched by Mr. Clarke to the American Chamber of Commerce of Paris and it, in turn, sent a letter to the Prefecture, asking special privilege for the writer and, within forty-eight hours, weeks of red tape were brushed aside, for a letter came by special messenger, addressed to M. L'Inginieur — M. de Buffevant — who is in charge of the Public Works at Versailles.

[1] Presented before the St. Louis Convention, June 4, 1930.

[2] Civil Engineer, New York, N. Y.

This letter did not guarantee anything, as we later found out, but it enabled us to secure an appointment with Mr. Engineer, who is a very important person in France.

On a dark morning in January — the sun rose about 9:30 there — we started for Versailles with our family and courier. We first visited Marly to see the pumping station and, what a pumping station!

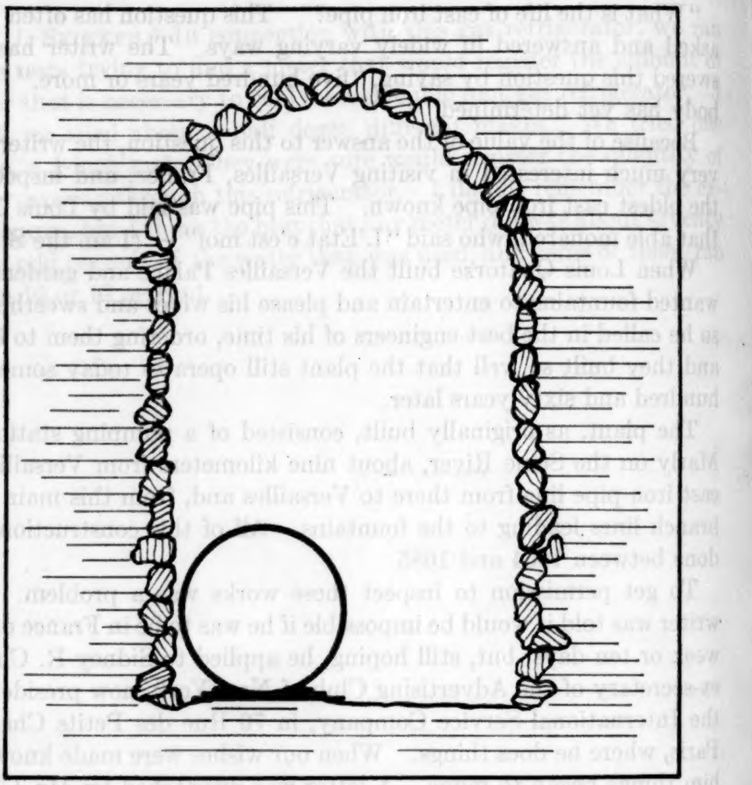

FIG. 1. APPROXIMATE SHAPE OF TUNNEL UNDER THE VERSAILLES GARDENS WITH THE PIPE LAID ON THE FLOOR

The pumps are exactly as originally installed (although various parts have been renewed). The pumps consist of immense undershot water wheels which operate two single acting plungers in cylinders of about 20 inch diameter and a stroke of perhaps six feet. The water wheels are 35 to 40 feet in diameter and some forty feet in length and look like much enlarged paddle wheels on Mississippi River packets.

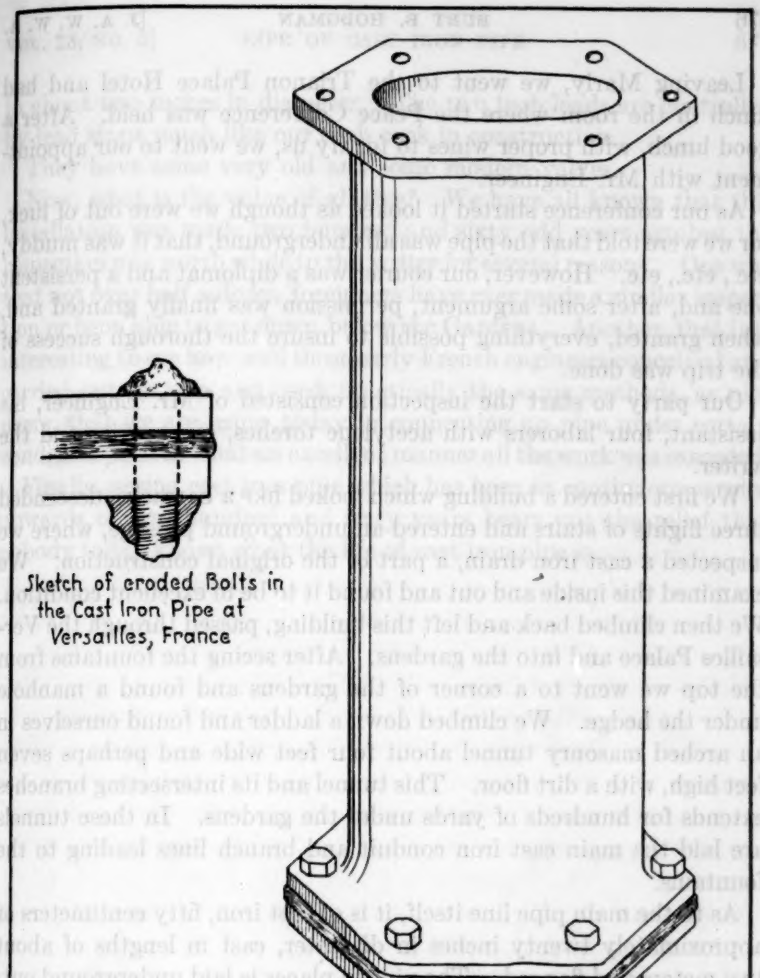
Sketch of eroded Bolts in the Cast Iron Pipe at Versailles, France
Sketch of Flange Bolts in the Cast Iron Pipe at Versailles Gardens, France

FIG. 2

Leaving Marly, we went to the Trianon Palace Hotel and had lunch in the room where the Peace Conference was held. After a good lunch, with proper wines to fortify us, we went to our appointment with Mr. Engineer.

As our conference started it looked as though we were out of luck, for we were told that the pipe was all underground, that it was muddy, etc., etc., etc. However, our courier was a diplomat and a persistent one and, after some argument, permission was finally granted and, when granted, everything possible to insure the thorough success of the trip was done.

Our party to start the inspection consisted of Mr. Engineer, his assistant, four laborers with acetylene torches, our courier and the writer.

We first entered a building which looked like a barracks, descended three flights of stairs and entered an underground passage, where we inspected a cast iron drain, a part of the original construction. We examined this inside and out and found it to be in excellent condition. We then climbed back and left this building, passed through the Versailles Palace and into the gardens. After seeing the fountains from the top we went to a corner of the gardens and found a manhole under the hedge. We climbed down a ladder and found ourselves in an arched masonry tunnel about four feet wide and perhaps seven feet high, with a dirt floor. This tunnel and its intersecting branches extends for hundreds of yards under the gardens. In these tunnels are laid the main cast iron conduit and branch lines leading to the fountains.

As to the main pipe line itself, it is of cast iron, fifty centimeters or approximately twenty inches in diameter, cast in lengths of about two meters and flanged. The pipe in places is laid underground outside the tunnel and, at others, runs along on the floor of the tunnel. The outside of the pipe, which apparently was never painted or coated, is in excellent condition. The crest of Louis XIV — the Fleur de Lys — was in evidence in several places.

The pipes were bolted together with steel bolts which have been renewed from time to time. The old bolts are so badly eroded that it would be hard to recognize either the head or nuts as such. The original gaskets between the joints were leather, about one-quarter inch in thickness. Where joints have been removed and replaced, lead gaskets have been substituted.

The leads to the fountain are of lead pipe varying from about six

to about two inches in diameter. The two inch leads are controlled by lead stops much like our curb cock in construction.

They have some very old and some modern valves.

Now, what is the value of all this? We have all known that this installation was made two hundred and sixty odd years ago but the inspection was worth while to the writer for several reasons. One was that not over half a dozen foreigners have ever made a similar inspection or been able to get down below the Gardens. Another, that it is interesting to see how well those early French engineers conceived and carried out an idea and used practically the same methods, as pioneers, that we are using today in connecting up pipe under certain conditions, and in what an excellent manner all the work was executed.

Finally, seeing cast iron pipe which has been in continuous service upwards of two hundred and sixty years bears out the relief that nobody today knows what the life of cast iron pipe is.

THE WATER AND SEWERAGE WORKS OF MOSCOW, U. S. S. R.[1]

By Isaac S. Walker[2]

About 10 months ago it was the privilege of the speaker to visit Moscow, to study and report upon projects for additional water supply and sewerage works for the city, as now contemplated by the Russian Government. Needless to say, in view of the many conflicting stories of Russian activities, it was the most interesting and illuminating experience in my career.

Immediately following my arrival in Moscow, on May 31, my first three weeks were spent in an intensive program of inspections of existing works, and proposed new sites and in numerous conferences with engineers and officials. The water and sewerage works are under the direction of the so called "Water and Canalization Trust," headed by a commissioner or commissar. In both departments I was impressed by the technical skill of the designing and supervising engineers and chemists and by the exhaustive study given to the comprehensive plans for both water and sewerage works. I found an exceptionally complete set of studies, reports and records, covering the proposed extensions, together with contour maps, plans, descriptions, meteorological records and other necessary engineering and analytical data on existing works.

The study of the water and sewerage problems for a city of 2½ million people, is no light problem at best, but here the difficulties were multiplied owing to my ignorance of the language and the necessity of acquiring all information through an interpreter. Hundreds of girls are acting in this capacity, but I was assigned a young man of 19 years, who had some experience in the technical work of the department, and I cannot compliment this boy too highly. Never outside of Russia, he spoke five languages fluently. His ability in interpretation was remarkable, which was of great help in the investigation and translation work.

[1] Presented before the Four States Section meeting, March 31, 1931.

[2] Consulting Engineer, Philadelphia, Pa.

Moscow, as you know, is the capitol and largest city of the Soviet Republics. It lies near the center of the East European Plain, about 56 degrees N. Latitude and 37½ degrees E. Longitude, on the Moscow River. It is the greatest city of industry and trade. Eleven railroads radiate from Moscow to all sections of the Union.

The average yearly temperature is about 50°F. The winters are very severe, lasting about 5 months, but the summers are hot. Rainfall records, covering the last 35 years, are available, showing an average of about 21 inches at Moscow.

The population in 1929, according to Water Department figures, was almost 2½ million. An increase to 4 million is anticipated by 1950, within the present limits, which cover about 81 square miles of territory. It is expected, however, that due to further expansion beyond present limits, Greater Moscow, in 1950, will have a population of 6 million, and plans for future water and sewerage works are being projected on this basis.

The city, which dates from about the year 1150, has grown in a series of concentric zones around the Kremlin, the inner walled city, with encircling ring streets and boulevards and a ring railway at the limits of the present outer zone. The surface of the city is moderately hilly, with elevations above mean sea level ranging from 400 to 550 feet.

THE MOSCOW WATER SUPPLY

The first public water supply for the city was built about 150 years ago, during the reign of Catherine the Great. The water from some large springs about 10 or 12 miles from the city was collected and conveyed in a brick aqueduct, across the valley of the Ruza River, to a distributing point in the city. This served for almost 50 years, or until about 1825, when the aqueduct broke. Following this a pumping station was built, and the first cast iron pipes were laid to carry the water to a tower in the city, which supplied the head for a number of distributing fountains. This old tower is still standing, and in use as a museum.

This system served until about 1860, when a well system was constructed at Mitishensky, another pumping station built, and about 30 miles of cast iron distribution pipes were laid. At this time, however, there was no water in the houses, and the total supply was only about 2 m.g.d.

During the next 40 years, the well system was further developed

and two imposing pressure towers were built in the city; but Moscow was still far behind other large European cities in water supply facilities. Even in 1900 the total public supply was only about 4 m.g.d. for a population at that time of about one million.

About 1898, however, a sewer system was constructed and comprehensive plans made for a new water supply. As the available yield from the wells was inadequate, the engineers turned to the Moscow River.

The river has its source about 110 miles west of Moscow, and flows into the Oka River about 80 miles southeast of the city. Due to its winding course, however, it has a total length of about 300 miles. The water-shed, above the water works intake, is about 2840 square miles. At Moscow the river has a width of 175 to 200 feet. Below the city the river is navigable, forming a branch of the Volga River navigation system. There is a substantial population on the watershed, and as the river also carries high turbidity at times, especially during the ice break-up in April, careful filtration is necessary.

The first installment of the filtration system was completed about 1903 and comprised an elaborate intake structure, pumping station, sedimentation basins, slow sand filters, a filtered water and a distributing reservoir. The latter is located on an elevation in the city, known as Variobesky Hill. The filter plant is located near the village of Rubleva, about 30 miles above the city center, measured along the winding river, but only about 10 miles by air line.

Additions to the filter plant have been made from time to time, and the system improved by the installation of preliminary filters, and coagulation and chlorination facilities. As it now stands, the filtration system of Moscow is quite similar to the present double filtration system of Philadelphia, and comprises two large pumping station structures, high and low duty pumps, operated by steam, Diesel engines and electric motors, six large sedimentation basins with 10-hour retention period, 80 pre-filters, operated at a rate of about 40 million gallons per acre per day, and 22 slow sand filters, $\frac{3}{4}$-acre each, operated at a rate of about 4 million gallons per acre per day. The preliminary filters are not equipped with operating tables and hydraulic valves, such as we provide in our modern plants, but efficient controllers are provided, for both the preliminary and final filters.

The total output of the filter plant at the present time, is about 60 million gallons per day. The well system, which has been recently

modernized with electric pumps, furnishes about 7 millions, making a total for both systems of about 67 m.g.d.

I was particularly impressed by the skilled technical control and supervision of all departments of the water works and with the measures taken for protection of the supply. All plants are enclosed and under strict guard, and no outsiders are admitted except by pass. So called sanitary protective zones have been established, for both the river and well supplies. Above the Rubleva intake there are several towns of substantial size, also many small villages and a number of factories, sanatoriums, rest homes, etc, which constitute a menace to the supply. In order to protect the river and its tributaries from sources of pollution, a sanitary protective zone was established as early as 1915. This zone extends for a length of 50 miles above the intake and covers an area of 775 square miles. The officials in charge of the zone are responsible for the general sanitation and improvement of the villages, factories and other institutions, the establishment of water supplies and sewage treatment plants, investigation of water borne infections, etc. In some sections of the zone the most extraordinary and drastic regulations are in effect, forbidding picnics, excursions, bathing, and pasturing of cattle. In addition it is planned to remove many of the villages in these forbidden areas. Such procedures are apparently easy of accomplishment under Soviet rule, making their pollution problems simple of solution, in comparison with ours.

The general control of water supply sources, is under a commission, known as the "Commission for Control of Drinking Water and Sources of City Water Supply," which name is generally shortened to "Filtration Commission." The personnel of the commission comprises the important staff of the department of water supply, the managers of the water and sewage laboratories, the biologist in charge of the filter plant, the manager of the sewage department, a representative of the sanitary and epidemic section of the Moscow Health Department, sanitary physicians of the water supply and protective zones, a representative of the Sanitary Institute, and other invited specialists. In addition to general operation, the Commission has general control of all filtration construction and comprehensive planning of extensions to existing structures, ways and means to improve the quality of the supply, and control of the sanitary protective zones.

The plants are operated under strict laboratory control. The

laboratories are well equipped for routine procedure and research work. Practically all the laboratory workers are women, especially trained for the work. Daily analysis are made of the raw, settled, pre-filtered, final filtered and chlorinated effluents. Complete chemical analyses are made at regular intervals, also analysis of samples from the distribution system. Residual chlorine tests are made every two hours of the water entering and leaving the filtered water basin.

Considering the vague ideas I had of Russia before my visit, I must say that some of these unformed impressions underwent a radical change after inspection of the water and sewage works, and contacts with the engineers, chemists and operators in charge. I was, to say the least, a little bit surprised to find works of such high class character, remarkably well operated, and producing a water supply of limited quantity, but of superior quality, of which any city might be proud, and to brush shoulders with men of the highest scientific skill and technique in the fields of water supply and sewage treatment.

The personnel of the water department numbers about 900. In addition to the head officials, I was impressed by the caliber of the plant superintendants, foremen and mechanics. On 5 or 6 occasions during our visits to different plants, the operator in charge was called upon to give a lecture outlining his plant and its operation, before our inspection. In all cases this was done by the operator in a creditable manner, showing a thorough knowledge of his subject. All the plant workmen I saw were apparently on their toes, and keenly interested in their work.

The plants looked well from the standpoint of appearance and general upkeep. Consideration is given to making a good impression on visitors, for at the filtered water basin, and also in the distribution reservoir, inspection wells have been arranged to show off the filtered water to advantage. The wells are lined with white tile and an excellent lighting effect provided, by means of green glass in some of the windows. They propose to install submerged electric flare lights in both wells.

All plants are well equipped with work and repair shops. The main repair shop is located at the Mitischensky pumping station, and is particularly well equipped with about 60 different machines, mostly of German make. All machine tool and die work is standardized. The meter repair shop is also well equipped with modern testing and repair apparatus, including several multiple test benches. All ser-

vices in Moscow are metered, and have been for many years. Large meters of 1½-inch diameter and over are purchased in Germany, but the smaller sizes, also of the Siemens & Halske German velocity type, are manufactured in Moscow and Kiev.

One of the most outstanding items in plant statistics, is that with a population of about 2½ million, of which about 1,800,000 receive water in their homes, there are only about 16,000 meters in service. In fact the total number of separate services listed is only about 12,000. This is accounted for by the fact that individual homes of the type we are accustomed to are very infrequent in Moscow. The city is greatly overcrowded, and the people live generally in apartments, flats, tenements, or otherwise in a few rooms in grouped buildings. One listed service, therefore, may supply a group of such buildings, or a "holding" as it is called, in which possibly 2 or 3 hundred families may be housed. All service lines are laid not less than 7 feet deep and street mains 10 feet deep, on account of deep frost penetration.

Distribution pipes are all cast iron of Russian manufacture, laid with lead joints, and aggregate about 500 miles in the entire system. About 55 percent of the total city area is piped. Pressures vary from about 30 to 100 pounds per square inch. Gate valves are generally of the Ludlow type, and are all installed in brick manholes. On my arrival in the City, I looked in vain for fire hydrants, but later found they have about 5300 in the system, located in manholes near street intersections. Portable hydrants with hose outlets are carried by the fire and street departments, and when needed, are clamped or bolted to the riser in the manhole.

All water is sold in Moscow by meter registration, at a fixed rate to workers of 13 Kopecs per 100 pails, equivalent to about 20 cents per 1000 gallons. Private industries, however, must pay substantially higher rates.

As I stated previously, the present population of the city is nearly 2½ million, of which about 1,800,000 are receiving water in their homes. In addition about 390,000 are served by street hydrants for common use, similar to the old street pump. Considering the entire population the per capita consumption is equivalent to about 26 gallons per day, a very low figure in comparison with our cities.

FUTURE WATER SUPPLY PLANS

With the city growing rapidly, and the demand due to the industrial and general development, increasing, an immediate need for an ad-

ditional supply is imperative. In supplying this need, and providing for an estimated population of 6 million by 1950, the engineers are confronted with some very interesting problems. The project calls for an increase in the available supply by 1950, up to 300 m.g.d., equivalent to 50 gallons per capita. The 1950 population estimated at 4 million within the present city limits, however, will be furnished with about 66 gallons per capita, and the 2 million in the new outer suburban zone, about 26 gallons per capita. These figures, while much lower than our American practice, are somewhat higher than present general European practice.

The problems of the future supply have been carefully studied for a number of years, and several different projects have been investigated in great detail, with lengthy reports prepared thereon. My time will not permit me to dwell on these interesting studies, on which volumes have been written, but briefly the situation is about as follows.

Three principal sources are available; the Volga River which is about 70 miles north of the city; the Oka, about 70 miles south, and the Moscow River, the present main source. The Volga and Oka are both large rivers, with minimum flows about 5 times as large as the Moscow River and are each sufficient to supply the city. At the sites investigated both rivers are of excellent quality, comparatively free from pollution. The water normally is clear, but becomes turbid at times, so filtration is necessary. The river levels are approximately the same as the Moscow River at the city, and pumping is required. The necessary long pipe lines to the city make the project very expensive. Large sized experimental rapid sand filter plants have been maintained at both rivers for a period of years, and the department is well posted on the necessary methods of treatment. Of the two, the Oka is preferred, as the water of the Volga becomes highly colored during drought periods, increasing the expense of treatment. The Oka is free from color and a generally excellent source of supply.

The minimum flow of the Moscow River at the present intake is about 195 m.g.d. Of this amount, however, about 130 m.g.d. must be permitted to pass the intake in order to maintain navigation below the city, thus leaving only 65 m.g.d. available for water works purposes. The limit is now about reached with the present plant, necessitating immediate steps for an additional supply.

Owing to the great initial expense involved in bringing in supplies from the Oka or Volga, the department has made exhaustive studies,

and is now proceeding with a plan to increase the minimum available yield of the Moscow River from 65, as at present, to 300 m.g.d. in 1950, by means of regulation and impounding reservoirs on the upper reaches of the river and its tributaries, the Ruza, Estra and Ozerne Rivers.

The first step, now under construction, is a roller lift regulating dam across the Moscow River, just above the present intake, with 2 steel rollers approximately 100 feet long and 12 feet diameter. This type of dam is selected owing to ice conditions during the spring break up. This dam, it is calculated, will permit taking about 90 m.g.d. at the intake. The present double filtration plant is now being extended to handle this quantity. Following this, all future filter plants will be of the American rapid sand type.

As required, great impounding reservoirs will be constructed, first on the Estra River, then on the upper Moscow and the other tributaries, storing the water during the flood periods, and releasing it during low flows, to run down the stream channels to the present filter plant site.

The thoroughness of the studies for this project, reflect great credit on the Department Engineers. It is a most interesting study in water conservation. The plan lends itself to gradual extensions as required; the ultimate construction costs are figured to be only about 60 percent of the Oka pipe line project, and the operating costs substantially less. Unfortunately the requirements for the greater city, by 1950, will exhaust this supply, unless extreme development of the water-shed is resorted to, so steps must be taken before then, to secure a new supply from the Oka River. This plan further commits the city to a nearby source, practically within city limits, with the involved sanitation and pollution problems of a thickly settled territory.

SEWERAGE AND SEWAGE TREATMENT

The related subjects of sewerage and sewage treatment as practiced in Moscow are also of great interest, but as my time is limited I will give you just a brief outline of the general situation.

The principal works comprise a separate sewer system, pumping station, extensive sand filtration fields at Lublino and Lubertzy, and the new Koguhovsky aeration plant.

The first installation of the sewer system, and the treatment works at Lublino, was begun in 1893 and completed in 1898. At the present

time there are about 380 miles of sewers in the city, generally of tile and brick. Connection to sewers is obligatory.

The main sewage pumping station has been operating since 1898. It is well equipped with modern centrifugal pumps, operated by Diesel engines and electric motors. About three quarters of all the sewage of the city requires pumping. The sewage is far more concentrated than American sewages. The total volume handled amounts to about 70 percent of the water supply. One rather unusual feature is the screening arrangement ahead of the pumps, consisting of a series of vertical bar screens spaced about 1 inch in the clear, with a motor operated cleaning device, discharging on a belt conveyor that carries the sewage to a grinder. The ground up matter falls back into the inlet channel to be rescreened, the process simply preparing the sewage for passage through the pumps, all matter other than large objects passing to the treatment works.

From the pumping station, the sewage may be pumped to anyone of the three treatment plants. At the present time about 90 percent of the total is handled at the two filtration fields at Lublino, located about 9 miles southeast of the city, and at Lubertzy, which lies about 12.5 miles east. The fields cover vast areas, about 4300 acres, or almost 7 square miles being under irrigation. Large additional areas are available for extensions. The soil is sand formation, and the beds are of sand, with underdrains discharging into the main drainage channels, thence to the river.

The filtered effluent from the newer Lubertzy plant, built in 1912 is excellent. Portions of the first Lublino plant have been in use for over 30 years and the capacity of the filter beds is decreased. At the present time this plant is seriously overloaded. Only part of the sewage at these plants is settled prior to discharge on the sand areas, but additional settling tanks together with separate sludge digestion tanks and sludge beds are planned. At the Lublino plant, about one million gallons per day is treated by sedimentation and contact filters. Here also is located an experimental biological station, built over 30 years ago, which regularly treats about 300,000 gallons per day. I believe this was one of the earliest sewage experimental plants in Europe.

The latest plant is the Koguhovsky Aeration Station, located on the Moscow River, about 6 miles south of the city center and put in operation about one year ago. It is a complete activated sludge plant, comprising a machinery and administration building, screens,

screenings incinerator, primary and secondary settling tanks, degreasing compartment, aerating and reaerating tanks, aerating trickling filters, sludge beds, a large fish pond and chlorine disinfection.

Before building this, experimental work was carried on at the Lublino Experiment Station. The present plant includes some novel construction features and is treating about $3\frac{1}{2}$ m.g.d. Extensions are being made to increase the capacity to 10 m.g.d. and will include separate sludge digestion tanks, equipped to utilize the digestion gases for heating the sludge chambers. One of the outstanding features is the aerating trickling filters, of which there are 12 in the present plant and on which the sewage from the secondary settling tanks is sprinkled in the usual manner, controlled by Miller siphons. The filters are of slag, 13 feet deep, placed in concrete boxes, with an air chamber underneath. With the forced air method, these filters are operated at a rate of 8 to 10 times the customary rates for strong European sewage. The plant is producing an effluent of exceptionally high quality.

The expense of additional sewerage and sewage treatment works for Greater Moscow will run into large figures and the problems have been approached in a business-like manner, with a carefully studied comprehensive plan, setting forth proposed extensions of main sewers and treatment works for each 5 year period, to 1950. The Russian engineers approach problems with great care and consideration on matters of such magnitude. The Koguhovsky Activated Sludge Plant, while it will assist in relieving the present immediate need for additional treatment facilities, is considered more or less as an experimental station, the aim of which is to obtain actual working data showing the technical and economic value of such intensive treatment, as compared with the older methods.

GENERAL

Judging from the hundreds of questions asked me since my return from Russia, it appears very few people here have any conception of the country or its people. To many, I believe this brief outline of the activities of the Russian Government in their water and sewerage work may be somewhat of a revelation. This paper is not the place for a discussion of general conditions, and not being a profound student of world economics, I do not consider myself qualified to pass judgment on, or forecast the outcome of what is frequently referred to as the greatest experiment in government in the world's history.

I may say, however, that the entire country, or at least what I saw of it in Moscow and vicinity, is a bee-hive of energy. Everyone appears to be working, with an aim in view, and unemployment is apparently not a problem in Russia. All endeavors appear to be directed toward the consummation of the 5 year plan, which, in its general scope, is said to be the most outstanding and comprehensive program ever inaugurated by any nation, calling for the expenditure of some 35 billions of dollars for economic reconstruction of the country within that period. As to the ultimate outcome, I can say only that, judging from my own limited observations, if all other activities of reconstruction, development and governmental functions are carried forward with the same degree of intelligence, skill and technical administration, as is evidenced in the water and sewerage works of Moscow, there is some hope of a bright day dawning for the Russian people.

UNUSUAL COLOR REMOVAL PLANT[1]

By Carl Wilson[2]

Wilmington and San Pedro, California, formerly independent cities, were annexed to Los Angeles in 1909, becoming what we now describe as the Harbor District. The water supply for Wilmington was furnished by the Seaside Water Company, which put down two wells in 1902 and a third in 1908. The Los Angeles Water Department took over this system in 1912 and has operated it continuously since that year. At present we have eleven wells at the original location and four new ones at Lomita, some two miles to the west.

The water derived from these wells is from the underground flow of the Los Angeles River, but it has been so profoundly altered during the latter part of its travel as to no longer resemble the supply taken from the same river above the Narrows for use in the city proper. Naturally one expects water to increase progressively in hardness as it moves through lime bearing strata, and we find this to happen here until the Harbor District is reached. During geologically recent periods, the California coast has been alternately elevated and depressed and during the process there was formed a deposit of peat extending from Signal Hill on the east to the Palos Verdes Hills on the west, and underlying Long Beach, Wilmington, and Lomita. The beds are encountered at a depth of about 350 feet beneath the surface, and wells 900 feet in depth are still in the same material at the bottom. The originally hard Los Angeles River water, as it percolates through the peat, suffers a remarkable transformation. If the distance traversed in the peat be sufficient, calcium, magnesium, and sulphates are completely removed, but our supply still contains the earths, although in what Californians regard as small amounts, while sulphates are found only in traces. Thus it happens that this area, surrounded by typically hard waters common to the region, is blessed with soft water which may be used in boilers for years without

[1] Presented before the Water Purification Division, the St. Louis Convention, June 5, 1930.

[2] Director of Sanitation, Department of Water and Power, Los Angeles, Calif.

depositing scale. The price paid for this outstanding advantage is amber color, amounting to from 100 to 125 parts per million, some hydrogen sulphide and a heavy load of organic matter.

As would be expected, water as it leaves the pumps contains very little dissolved oxygen, and, consequently, because of its high organic content, it spoils quickly in the distribution system. In fact, it will not keep for more than thirty-six hours, causing much wastage through blowing off dead ends and mains where flow is sluggish due to light consumption.

As the water comes to the surface it is perfectly free from suspended matter, but when held in a bottle or other container for thirty-six to forty-eight hours it first becomes uniformly turbid and later black filamentous masses of bacterial growths separate out, giving a most unsightly appearance to the water, while the accompanying odor is offensive.

Because of these disadvantages considerable time has been spent to ascertain the best manner of treatment. Aluminum sulphate was tried first, and with a dosage of four grains per gallon about half the color could be removed. Potassium alum gave equally good removal in smaller doses, but the cost was considered prohibitive. Potassium permanganate as an oxidizing agent, followed by aluminum sulphate, gave a complete color removal, yielding a sparkling product, but at a cost of $30.00 per million gallons. Moreover, residual manganese was considered too high. Chlorine could be made to bleach the water, but de-chlorination was so difficult as to be considered impracticable.

FERRIC CHLORIDE FOR COLOR REMOVAL

In the meantime, ferric chloride appeared on the local market in 50 percent solution at a particularly attractive price, so it was tried on the Wilmington water. The success was immediate and complete as far as laboratory tests were concerned, and the estimated cost of its use was only $6.00 per million gallons. As a result of this work it was decided to build an experimental treating plant at the wells for a complete study of the process. The design provided for a capacity of 69,000 gallons per day at conventional filtration rates of two gallons per square foot per minute, and comprised a baffled mixing and reaction chamber sufficient to give a retention period of one hour, followed by a filter having an area 4 by 6 feet, of standard design, but with glass panels extending from the coarse gravel to the

flow line to enable observation of conditions within the filter, particularly during backwashing. However, the sand used in the filter was not of the usual standard, for we were too impatient to wait until the beautifully white and carefully graded sand from Monterey could be obtained. Instead, we used a coarse granitic sand which is abundant close at hand. It was screened to a grain size about three times as large as the sand generally used. In all other respects the filter as designed conformed to usual practice. The lips of the wash trays were placed twenty-four inches above the sand surface, but provisions were made to vary this distance if necessary. The sand bed was thirty inches in thickness. Clear water and waste wash water tanks were also provided. A 4-inch motor-driven centrifugal pump was employed to backwash, and by means of manifolds on suction and discharge, it also pumped the settled wash water back to the reaction chamber to avoid waste. A Trident meter measured all water entering the plant, enabling a close check upon performance.

At the outset the plant was operated at a rate of 69,000 gallons in 24 hours. The product met all expectations, but the hydroxide floc did not perform according to program. We had provided sluice gates at the bottom of each compartment of the reaction chamber so that the accumulation of floc could be drawn off, but, instead of settling to the bottom, the hydroxide insisted upon forming a thick scum on the surface of the water. Although we knew our water carried large quantities of methane we had not taken that fact into consideration until we found the gas buoyed the floc so persistently that new slucies had to be installed at the top of the chamber.

We quickly found that backwashing could not be successfully done because the floc would not rise high enough to enter the trays, so the trays were lowered a few inches at a time until their lips were only 10 inches above the sand. By this time growths in the upper sand made new troubles in backwashing, so we next cut the sand to eighteen inches in thickness, with marked improvement. Finally the sand thickness was reduced to ten inches, with the wash trays ten inches above the sand surface and this proved to be the best arrangement. However, growths still took place in the sand, causing caking and uneven backwashing. At the same time Crenothrix appeared in the filtered water after standing 48 hours, although the residual iron was only one part in forty millions! Accordingly, chlorine was introduced as the water entered the filter, with the intention of main-

taining a readable trace of residual chlorine in the effluent, but we were unable to apply sufficient chemical to give a positive reading in the filtered water. It was all consumed by organic matter in the sand! We removed both sand and gravel, rejecting the former and scrubbing the latter with chlorine solution. The filter chamber was also sterilized by a strong solution of hypochlorite which was allowed to act for twenty-four hours, and the filter material replaced. This time chlorine was applied at the start of the run and fed continuously and complete control of all growths was obtained with a residual of 0.1 p.p.m. in the effluent.

Backwashing still left irregular deposits of ferric hydroxide here and there on the surface of the sand, and to overcome this S. M. Bennett, the plant operator, suggested the use of a distribution grid on the sand surface to distribute the incoming water, and accordingly a duplicate of the usual backwash grid was installed, with the orifices so placed as to deliver water parallel to the sand surface. This solved our last troubles, and thereafter backwashing gave a perfectly clean sand bed in less than one minute, and with a water consumption of less than 3 percent of the water filtered.

RETURN OF FERRIC HYDROXIDE FOR COLOR REMOVAL

The plant was operated continuously for three months and at increasing rates of flow until finally we were filtering 6 gallons per minute per square foot, or three times the designed rate, and with a product which left nothing to be desired. The dosage of ferric chloride actually used at these high rates was only 0.1 g.p.g. as Fe_2O_3 or 0.2 g.p.g. as $FeCl_3$. This dosage was so small as compared with the alum requirements that we suspected there must be some catalytic effect exerted by ferric hydroxide. To test this theory we prepared chemically pure ferric hydroxide and added it to the highly colored raw water, and after fifteen minutes agitation, filtered in the usual way. The result was perfectly colorless water with all the troublesome organic matter removed. The success was so complete that we decided to try using the hydroxide sludge a second time, and we were again rewarded with perfect water. This re-use of the same portion of hydroxide sludge was repeated until, after the eleventh successful return, the experiment was concluded.

DESIGN OF LARGE PLANT

As a result of these experiments we have designed two plants, one of 5 and the other of 15 m.g.d. capacity. The innovations included

are, coarse sand, used in a bed only ten inches in depth, with the influent water distributed in the manner described, wash trays with lips ten inches above the sand, glass observation panels in each filter unit, and continuous sludge return with mechanical agitation in the reaction chamber. The latter feature was incorporated because it was found that violent agitation causes the hydroxide floc to settle completely in a very few minutes so that the load carried to the filters is greatly reduced, resulting in longer runs between backwashings.

There are some difficulties encountered in feeding ferric chloride solution, and to overcome these the author has devised a clock driven, displacement feed machine which automatically adjusts the amount of chemical applied to fit fluctuations in the flow of water. These machines, which are being built in our own shops, include meters to record the total volume of water passing, and a rate of flow indicator to facilitate dosage control.

ADVANTAGES OF FERRIC CHLORIDE

Among the advantages obtained through the use of ferric chloride in this water are:

1. Complete color removal at low cost.
2. Freedom from the delayed precipitation which causes unusual trouble in this water.
3. More rapid filtration, due to the nature of the floc, which permits the use of coarser sand in thin beds.
4. Better backwashing because the floc remains on the sand surface instead of penetrating into the bed.
5. More rapid coagulation and sedimentation permitting shorter retention.
6. Economy in structures, as due to the speedy reaction of ferric chloride and the high filtration rates, the retention chamber and filter units may be much smaller than usual.

One unique possibility suggests itself as of advantage under special circumstances where no increase in dissolved solids, or change in hydrogen ion content could be permitted. Under such conditions pure ferric hydroxide could be added to the water, followed by violent agitation for 15 to 30 minutes. After a short sedimentation and filtration the water would be unchanged except for the loss of color, organic colloids, and suspended matter. No addition of dissolved substances will be found in the effluent. The hydroxide

sludge could be returned for re-use, even in the case of turbid waters. It has been found possible in desilting experiments on Colorado River water to return the iron sludge, together with its load of silt, at least three times. The economies thus effected are considerable, and the results obtained in our experimental work left nothing to be desired.

DISCUSSION

J. Summie Whitener:[3] Dr. Wilson's paper gives a good description of the experimental filter plant and the various chemicals used in working out a treatment for colored water. The innovations, in the design of the two plants, are a decided departure from accepted standards of design and furnish food for thought to designers of colored water treatment plants.

A plant, which will completely and consistently remove color at low cost, should be considered as adequately designed regardless of precedent. The color content of a well water will remain fairly constant, but a given surface water will vary in its color content sometimes as much as 300 percent. Whether or not a plant can be built flexible enough to remove normal and various percentages of normal color with the same efficiency, can only be determined by further experiments.

Ferric chloride must undoubtedly form a quicker and heavier floc than most other coagulants as evidenced by the low retention period in the coagulation basin (1 hour). It must be of peculiar nature because of the removal of residual floc by coarse sand (effective size approximately 1 mm.), the low height of wash water trough above the sand surface (10 inches), and the high rate of filtration (6 gallons per square foot per minute).

The innovations in design, the excellent results obtained, and the decided reduction in plant construction cost, in my opinion, justify the construction of small experimental plants prior to the design of large plants. It is my belief that better plant efficiencies and lower construction costs will be obtained in the future by experimental plants proving that departure from standard design is advisable for certain waters. Standard design factors will nearly always be applied to small plants because their size necessarily limits the advantages of increased efficiency and lower construction cost.

It seems logical to me that the effective size, uniformity coefficient,

[3] Assistant Professor of Sanitary Engineering, State College of Agriculture and Engineering, Raleigh, N. C.

and depth of sand, height of wash trough above sand, and rate of wash may advisedly be varied for different types of water and different coagulants.

Dr. Wilson's experience with organic matter and growths in the the sand and their removal with chlorine are especially interesting to me because of my similar experience at the Raleigh, N. C., Filtration Plant.[4] Chlorination of coagulated water will, in my opinion, tend to eliminate organic matter and growths in the sand, cause more even washing, eliminate air binding, and reduce the cost of filtration by decreasing the amount of wash water. This statement is supported by the increasing number of plants in North Carolina that have benefitted by chlorinating their coagulated water.

L. L. HEDGEPETH:[5] The most remarkable thing about this paper is its incontrovertible argument for practical scientific investigation of the quality of a water supply as an important consideration in plant design.

Ten inches of coarse sand, ten inches freeboard, returned sludge used for coagulant, 376 million gallons per acre per day filtration rate, and as a climax, we are told that only by such radical departures from standard rates and designs could acceptable results be obtained. In this particular case, any other course than pre-investigation of treatment before design of plant would surely have led to failure. Is it not a good demonstration that similar scientific investigations of other water supplies would pay for themselves?

With respect to the chemical treatment involved, we were interested to ascertain if this type of treatment would be similarly applicable to a very highly colored swamp water and have requested T. R. McCrea, Chemist at the Elizabeth City, North Carolina, Water Works, to give us some results and comments on this method of coagulation applied to his raw water.

The water at this plant is taken from a tributary of the Great Dismal Swamp and is one of the highest colored waters in the United States undergoing clarification for municipal uses.

[4] Journal, February, 1929, page 258.

[5] Sanitary Engineer, Pennsylvania Salt Manufacturing Company, Philadelphia, Pa.

We quote him in full as follows:

"The water that Dr. Wilson deals with is turbid and only slightly colored as compared with the Dismal Swamp water. He uses precipitants to throw out color and turbidity. Such light color removal is done largely in the agglomeration (floc forming) interval through nascent ionic neutralization of negatively, as well as positively, charged color particles before molecular hydrous oxides are formed to enmesh turbidity factors. Therefore, when the hydrous oxides are formed, they are free to adsorb color. Dr. Wilson does well to return the precipitated oxides and take advantage of their adsorptive properties.

"In the treatment of highly colored water at our plant where turbidity is not a factor, necessity makes us take advantage of the ionic neutralization and the molecular adsorption of color to such an extent that our sludge is well spent when it settles. The settled sludge is sensitive and easily peptized, and under no conditions could we consider sludge return as a practice.

"Laboratory results are as follows:

PARTS PER MILLION				pH	SLUDGE FROM 2 VOLUME H_2O RETURNED TO ONE VOLUME	FINAL COLOR	PER CENT REMOVAL
Color	Turbidity	CO_2	Alkalinity				
480	0	18	20	5.4	1	400	0
480	0	15	18	5.2	2	480	0
480	0	15	18	5.2	3	480	0
1040*	0				1*	480 plus	0

* Water from Lake Drummond 1040 p.p.m. color precipitated and sludge returned to water of 480 p.p.m. Peptization was the result."

M. E. Flentje:[6] A recent experiment with ferric coagulants will probably be of interest here.

The Warren and Bristol Water Company of Bristol, R. I., has a soft raw water supply containing considerable color. The color range is from approximately 50 to 150 p.p.m. Normally, this water is treated with alum and whiting, or limestone flour. This is followed, after mixing, by filtration, lime addition for pH correction, and chlorination. The range in alum dosage is from 1.5 to 2.5 or 3 grains per gallon, and the variation in whiting dose is from 1.5 to 2.0 grains per gallon.

After some promising laboratory experiments on May 1 and 2, 1930, the color during this test was a minimum, 50 p.p.m., and the alum and whiting dose was 1.5 grains per gallon each, with a filtered

[6] Community Water Service Company, Harrisburg, Pa.

color of 10–12 p.p.m. With chlorinated copperas somewhat better color removal resulted with a dose of 1.2 grains of iron sulphate and slightly over the theoretical chlorine requirements. The plant effluent color during this test was 7 p.p.m. and this treatment produced a saving of approximately $1.00 to $1.50 per mg.

In this particular plant, chlorinated copperas offers some interesting possibilities, not only in the savings indicated, but also in simplifying the treatment. Whiting can be eliminated, and possibly final chlorination. Pre-chlorination can easily be obtained, and this undoubtedly will remedy some difficulties that have been experienced in keeping the filter sand of this plant in good condition. Very good and rapid floc formation takes place, although a definite minimum requirement of coagulant seems to be present.

THE DROUGHT OF 1930 IN WEST VIRGINIA[1]

By L. Kermit Herndon and James R. Withrow

The scope of this article includes observations made upon the effect of the drought of 1930 upon the State of West Virginia, with particular reference to rainfall data and the condition of the streams and the resulting effect upon public water supplies, stream pollution, public health and industry.

The data presented indicate that:

1. The drought of 1930 in West Virginia was of greater length and greater intensity than any drought previously recorded in the climatological history of the state.
2. The drought really started in December, 1929, and each succeeding month in 1930 showed a deficiency of rainfall up to December.
3. The average deficiency of rainfall for the state from December 1, 1929, to November 1, 1930, was 17.08 inches, with a maximum of 26.59 inches and a minimum of 8.20 inches.
4. Stream flow in the state established new records for minimum discharge, both as to quantity of flow and duration of the low flow.
5. Public water supplies suffered greatly both as to quantity and quality.
6. Certain industries were forced to close due to the low condition of the streams.
7. Public health was detrimentally affected by the drought due to effect upon the public water supplies and the lack of sufficient flow to dilute and carry away sewage wastes.

The same drought conditions covering Ohio and West Virginia were more acute in the latter state. The work of one of the writers as the chemical engineer for the State Water Commission of West Virginia upon stream pollution studies afforded an excellent opportunity to observe the conditions brought about by the drought in West Virginia.

[1] Contribution from the Chemical Engineering Department, The Ohio State University, Columbus, Ohio.

RAINFALL DEFICIENCY[2]

The West Virginia drought really started with December, 1929, during which month there was a deficiency of 0.79 inch of rainfall for the state. The deficiency for the state from December 1, 1929, to October 31, 1930, was 17.08 inches, with a maximum of 26.59 inches at Logan and a minimum of 8.20 inches at New Cumberland. This latter station and the next two immediately above it are in the narrow northern panhandle extending along the Ohio River between Ohio and Pennsylvania. The rainfall expressed in percentage of the normal rainfall for the months of 1930 is shown in table 1.

TABLE 1

Rainfall data for West Virginia

MONTH	RAINFALL	DEFICIENCY	NORMAL	PERCENT OF NORMAL
	inches	*inches*	*inches*	
December, 1929	2.51	0.79	3.30	76
January, 1930	1.86	0.47	3.09	49
February	3.21	0.73	3.94	85
March	1.95	1.57	3.52	82
April	2.17	1.74	3.91	55
May	2.87	1.60	4.47	56
June	1.90	2.59	4.49	*64*
July	2.28	1.90	4.13	*42*
August	1.45	1.57	3.02	54
September	2.00	2.16	4.16	48

With the periods:

	per cent of normal
January to September	*59*
March to August	*59*
July and August	*48*

Of the above figures those italicized are new records.

DROUGHT SECTIONS OF THE STATE

The entire southern end of the state with the exception of two small areas had a deficiency in excess of 16 inches, for the period December 1, 1929, to November 1, 1930. Only a small portion of this was in the range of 16 to 18 inches, the major part ranging from 18 to 26 inches.

[2] Climatological Data for the U. S., West Virginia Section, U. S. Weather Bureau.

TABLE 2

Variations from normal rainfall, West Virginia, 1930

Climatological data for the U. S.—U. S. Weather Bureau, West Virginia Section

	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	DEFICIENCY TOTAL
Eastern Sections:												
Bayard	0.52	−1.60	−0.37	−1.2	−0.75	−1.41	0.02	−2.30	−2.63	−1.54	−2.75	14.02
Brandywine	−0.79	−1.75	−0.78	−1.58	−1.34	−2.31	−0.31	−3.43	−1.58	−1.03	−0.77	15.67
Harpers Ferry	−0.32	−0.93	−1.16	0.30	−0.23	−1.26	−0.30	−3.28	−2.99	−2.09	−2.69	14.95
Martinsburg	−0.22	−0.77	−0.20	−0.54	−0.57	−3.08	0.64	−2.50	−2.73	−1.08	−2.09	13.14
Moorefield	−1.49	−1.28	−1.29	−1.23	−1.34	−2.52	0.97	−2.96	−2.28	−2.14	−2.10	17.66
Piedmont	−1.36	−0.97	−1.61	−1.68	−0.48	−1.43	−0.89	−2.20	−1.59	−1.31	−2.62	16.14
Northern:												
Bens Run	−0.37	−1.46	0.05	0.11	−2.42	−2.64	−2.43	−2.73	−2.10	0	−2.37	16.58
Buckhannon	1.99	−2.08	−0.77	−0.92	−2.46	−1.78	−0.81	−1.93	−2.55	−1.44	−2.08	14.80
Creston	−0.72	−1.32	0.43	0.19	−2.27	−1.94	−2.82	−2.72	−0.70	−1.55	−2.49	15.91
Dam 12, Ohio River	0.76	−1.27	0.57	0.75	−1.68	−1.43	−1.41	−1.12	−3.80	−0.49	−2.33	13.01
Dam 13, Ohio River	−0.57	−1.49	0.07	0.56	−1.46	−2.02	−1.45	−1.39	−3.10	−1.34	−2.26	14.45
Elizabeth	−0.85	−2.07	0.16	−0.51	−2.16	−2.45	−2.62	−2.73	−1.78	−2.21	−3.19	19.39
Elkins	−1.05	−2.23	−0.30	−0.33	−0.46	−2.07	−1.26	−2.37	−2.58	−1.71	−2.09	16.45
Fairmont	−0.75	−1.84	0	−0.77	−2.55	−1.44	0	−3.10	−1.77	−1.39	−2.15	15.76
Glenville	−0.92	−2.15	−0.37	−0.26	−1.68	−0.63	−1.94	−4.30	−1.19	−2.35	−2.26	18.05
Lost Creek	−1.59	−2.47	0.02	−0.48	−1.16	−2.52	−0.97	−3.28	−2.68	−1.39	−1.88	18.40
Mannington	−0.81	−2.47	0.36	0.89	−1.98	−2.01	0.09	−2.26	−2.06	−1.98	−2.15	14.30
Morgantown	−0.16	−2.45	−1.24	−0.70	−1.80	−0.71	0.81	−3.02	−2.30	−1.80	−1.52	14.89
New Cumberland	0.35	0.13	0.38	−0.18	−1.54	−0.93	0.48	−2.32	−1.61	−1.51	−1.45	8.20
New Martinsville	−0.41	−1.74	0.67	0.50	−1.94	−1.24	−1.81	−3.08	−2.55	−1.26	−1.98	14.84
Parkersburg	−0.55	−1.42	−0.83	0.66	−1.74	−2.09	−2.83	−3.05	−1.88	−1.75	−1.80	17.28

Philippi	−1.04	−2.32	−0.02	−0.30	−1.16	−0.66	−0.87	−1.02	−1.99	−1.37	−2.01	12.76
Pickens	−0.56	−2.59	−0.11	0.11	−1.83	−2.19	−3.23	−3.41	−2.66	−2.26	−2.90	21.63
Rowlesburg	−1.17	−2.28	0.56	−1.34	−1.09	0.33	−0.19	−3.08	−1.05	−0.95	−2.01	12.27
St. Marys	0.12	−2.23	−0.18	−0.71	−2.24	−2.14	−2.52	−3.32	−2.72	−0.52	−2.62	19.08
Terra Alta	−2.52	−3.52	−1.10	−2.62	−0.85	−1.64	−1.68	−3.51	−2.13	−1.66	−2.58	23.81
Wellsburg	1.28	−0.71	−1.38	−0.65	−0.45	−1.14	−0.85	−2.85	−2.01	−1.01	−1.66	11.43
Weston	−1.43	−2.04	−0.55	−1.00	−1.58	−2.64	−1.43	−3.88	−1.81	−1.78	−2.30	20.44
Wheeling	−0.23	−1.16	0.12	0.70	−1.66	−1.50	−1.59	−3.07	−2.80	1.08	−1.57	11.68
Southern:												
Bancroft	−0.91	−1.77	−0.64	−0.44	−2.76	−2.33	−2.26	−1.70	−0.54	−0.33	−2.35	16.03
Bluefield	−1.16	−1.18	−1.18	−2.14	−1.88	−1.16	−3.48	0.18	−1.18	−1.55	−1.99	16.72
Charleston	−1.67	−2.28	−0.78	−0.78	−1.65	−1.98	−2.85	−1.20	−0.81	−1.76	−2.12	17.88
Clay	−1.99	−2.09	−1.26	−0.15	−1.99	−1.51	−2.22	−2.13	−2.71	−1.40	−2.27	19.72
Dam 19, Ohio River	−1.57	−1.98	0.16	−0.27	−2.01	−2.66	−1.66	−2.30	−1.78	−2.37	−2.26	18.70
Dam 20, Ohio River	−1.33	−1.96	0.04	−0.42	−2.27	−2.34	−2.28	−1.75	−2.17	−2.13	−2.74	19.35
Gary	−1.75	−2.50	0.176	−1.44	−1.43	−0.96	−2.82	−2.19	0.40	−2.22	−2.16	21.05
Hinton	0.91	−1.80	−1.23	−2.04	−1.97	−2.25	−3.10	−2.36	−2.20	−2.21	−1.87	21.94
Huntington	−1.52	−0.186	−0.13	−1.74	−2.60	−2.16	−3.18	−3.21	−0.51	−0.94	−2.51	19.36
Kayforce	−1.43	−3.02	−0.56	−2.65	−2.57	−1.45	−3.99	2.30	−1.31	−2.70	−2.79	20.17
Logan	−2.35	−3.29	−0.06	−2.67	−3.69	−1.60	−3.72	−4.67	−0.64	−1.99	−1.91	26.59
Marlington	−0.03	−1.84	−0.96	−0.07	0.69	−1.24	−2.45	−4.41	−2.30	−1.82	−1.94	17.17
Pt. Pleasant	−0.74	−1.72	−0.19	−0.80	−1.83	−1.20	−2.59	−2.12	−0.93	−1.84	−1.43	15.39
Robertsburg	−1.67	−1.75	−0.34	−1.46	−2.47	−2.73	−2.90	−2.52	−1.14	−0.95	−1.91	19.74
Ryan	−1.47	−2.10	−0.49	−0.09	−2.37	−2.17	−2.46	−2.53	−1.17	−1.69	−2.59	19.13
Spencer	−0.01	−2.40	0.15	0.19	−2.24	−1.34	−2.67	−3.17	0.37	−1.87	−2.46	15.35
Sutton	0.39	−1.85	0.69	−0.36	−1.54	−0.14	−2.28	−3.37	0.26	−1.11	−2.04	11.35
Williamson	−1.01	−2.52	0.91	−0.54	−1.96	0.32	−1.99	−2.09	0.70	−1.12	−1.83	13.05
State	−0.79	−1.96	−0.47	−0.73	−1.57	−1.74	−1.60	−2.59	−1.90	−1.57	−2.16	17.08

The central part of the state ranged from 12 to 20 inches deficiency with the major part above 16 inches.

TABLE 3

Rainfall at Elkins

	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	YEAR
Normal	3.78	3.08	3.80	3.62	4.05	5.06	5.83	3.86	3.15	2.91	2.78	3.46	45.38
1899	4.26	4.04	5.12	2.69	6.12	5.98	5.87	1.43	5.01	1.15	2.04	3.64	47.35
1900	2.07	3.88	4.41	1.37	2.51	5.93	5.59	2.61	2.56	2.46	5.93	3.08	42.40
1901	3.65	1.17	3.50	5.61	5.95	5.94	2.98	4.43	3.14	0.50	2.90	6.92	46.69
1902	3.90	2.86	4.39	3.61	4.08	5.22	6.23	3.61	4.81	2.76	3.92	5.82	51.27
1903	3.79	5.72	3.64	3.38	5.37	5.51	3.60	2.48	1.69	1.79	2.71	2.16	41.84
1904	2.71	3.18	4.25	3.06	3.60	5.25	4.07	4.59	1.70	2.16	1.02	3.19	38.78
1905	3.48	2.32	4.89	2.96	5.41	3.93	4.56	3.97	1.83	3.70	2.30	2.29	41.64
1906	3.84	1.24	5.38	5.29	3.66	6.46	3.16	4.84	4.24	3.81	2.10	5.07	49.09
1907	8.93	2.87	4.75	3.90	3.21	7.26	11.10	5.27	7.10	3.73	3.84	3.41	65.37
1908	4.02	3.22	5.58	4.95	8.42	2.77	7.88	2.60	0.88	0.33	0.77	2.83	44.25
1909	2.98	3.20	3.28	5.39	2.96	7.78	4.85	3.20	4.30	4.58	2.31	2.02	46.85
1910	5.77	2.22	0.68	2.24	3.91	8.05	4.07	2.70	3.61	2.21	2.26	2.72	40.44
1911	8.04	2.18	4.75	5.26	2.23	4.97	3.67	10.42	6.87	6.11	2.75	3.30	60.55
1912	2.88	2.11	5.50	2.67	4.35	4.93	10.61	3.30	4.18	1.10	2.48	2.87	46.96
1913	5.30	2.24	3.11	3.75	5.63	2.83	8.67	4.56	5.09	6.23	5.47	3.45	56.33
1914	2.31	2.72	2.34	6.97	1.43	4.23	7.74	4.96	0.52	2.25	0.73	5.16	41.36
1915	5.14	2.62	1.69	2.28	2.86	2.45	3.40	6.21	3.04	4.42	3.10	4.04	41.25
1916	6.31	4.02	5.53	3.43	4.29	4.86	6.29	3.13	4.87	2.32	1.50	3.20	49.75
1917	4.58	3.79	7.12	2.72	4.35	3.52	2.69	3.26	2.83	2.97	1.23	1.17	40.23
1918	5.11	3.61	5.61	4.66	5.87	5.32	1.68	5.43	4.06	3.40	1.60	5.93	51.28
1919	4.20	2.04	2.76	1.94	3.88	6.40	8.75	3.09	2.28	5.69	3.25	4.73	49.01
1920	4.66	3.10	4.57	5.45	2.19	3.83	5.27	3.33	3.35	1.07	3.72	2.78	43.32
1921	2.50	3.09	2.92	2.26	4.21	6.08	4.69	6.82	5.15	3.30	5.40	5.07	51.39
1922	3.18	4.26	5.32	3.77	3.25	7.40	5.75	2.96	1.31	1.20	1.55	4.53	44.48
1923	5.10	3.73	3.32	3.20	1.96	6.94	3.73	3.08	2.33	0.89	3.28	6.95	44.51
1924	3.64	4.07	4.41	4.15	8.88	5.18	5.86	3.81	5.39	0.26	2.65	2.69	50.99
1925	4.12	1.97	3.91	3.32	2.60	6.11	4.81	1.18	4.55	6.85	3.21	1.52	44.19
1926	4.20	3.98	3.58	3.90	3.94	3.86	4.57	6.57	5.00	4.15	2.04	5.56	51.35
1927	4.19	5.71	2.81	7.25	4.13	5.25	7.35	5.08	3.47	4.56	4.47	3.43	57.70
1928	2.81	2.53	3.33	6.74	3.94	7.99	4.81	4.77	2.34	1.71	3.98	2.68	47.63
1929	3.21	2.58	3.42	4.49	8.09	4.62	5.26	1.81	3.28	7.28	4.55	2.41	51.00
1930	1.55	2.78	3.47	3.16	1.98	3.80	3.01	1.28	1.44	0.82	1.46	3.63	28.38

The northern part of the state along the Pennsylvania border was practically all in the 14- to 16-inch range with one high point of 20 inches deficiency.

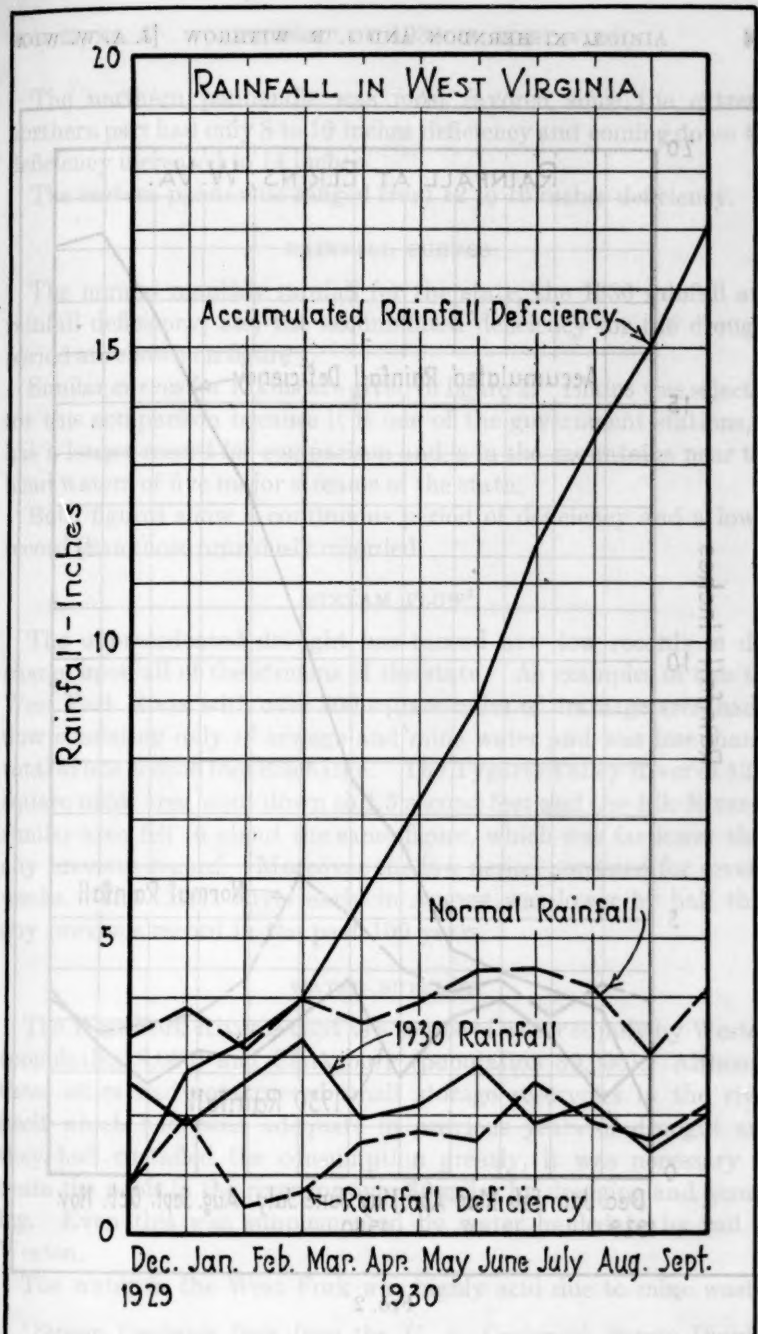
RAINFALL IN WEST VIRGINIA
Rainfall - Inches
20
15
10
5
0
Accumulated Rainfall Deficiency
Normal Rainfall
1930 Rainfall
Rainfall Deficiency
Dec. Jan. Feb. Mar. Apr. May June July Aug. Sept.
1929
1930

FIG. 1

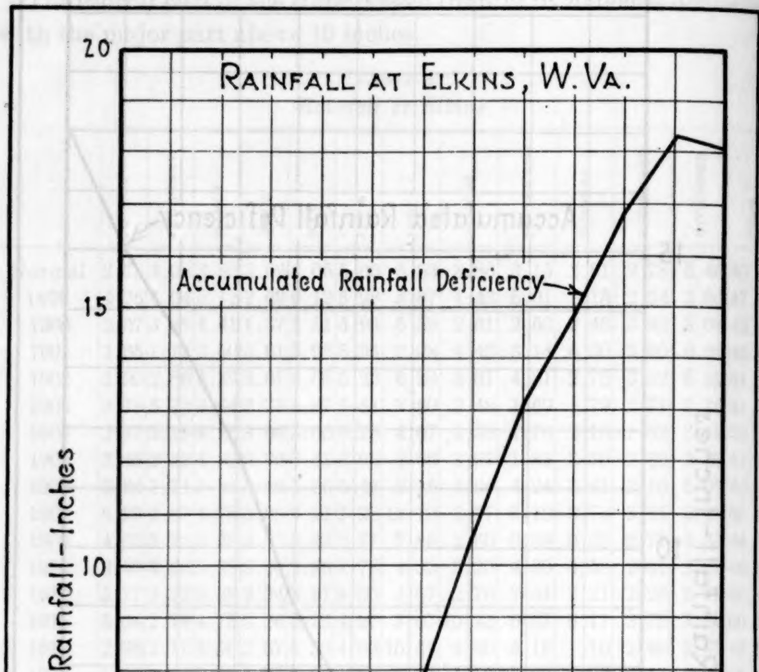
RAINFALL AT ELKINS, W. VA.
Accumulated Rainfall Deficiency
Normal Rainfall
1930 Rainfall
Rainfall - Inches
20
15
10
5
0
Dec. Jan Feb Mar. Apr May June July Aug. Sept. Oct. Nov.
1929
1930

FIG. 2

The northern panhandle was most favored since the extreme northern part had only 8 to 10 inches deficiency and coming down the deficiency increased to 14 inches.

The eastern panhandle ranged from 12 to 16 inches deficiency.

RAINFALL CURVES

The normal monthly rainfall for the state, the 1930 rainfall and rainfall deficiency, and the accumulated deficiency for the drought period are shown on figure 1.

Similar curves for Elkins are given in figure 2. Elkins was selected for this comparison because it is one of the government stations, it has a longer record for comparison and is in the mountains near the head waters of five major streams of the state.

Both figures show a continuous period of deficiency and a lower record than those previously recorded.

STREAM FLOW[3]

The unprecedented drought has caused new low records in discharge upon all of the streams of the state. As examples of this the West Fork River with over 800 square miles of drainage area had a flow consisting only of sewage and mine water and was less than a total of one second foot discharge. The Tygarts Valley River of 1200 square miles area went down to 1.5 second feet and the Elk River of similar area fell to about the same figure, which was far lower than any previous record. Moreover the low period persisted for several weeks. The Cheat River early in August was lower by half than any previous record in the past 100 years.

WATER SUPPLIES

The West Fork River is used as a source of water supply by Weston (population 8,000) and Clarksburg (population 30,000). Although these cities had constructed small storage reservoirs in the river itself which had been adequate in previous years of drought and they had curtailed the consumption greatly, it was necessary to drain the pools in the river for over 30 miles by dredging and pumping. Even this was supplemented by water hauled in by rail at Weston.

The water in the West Fork was highly acid due to mine wastes

[3] Stream Discharge Data from the U. S. Geological Survey Division Engineer, Wm. Kessler, or from measurements by L. K. Herndon.

(average pH 2.8) and very corrosive. The hardness rose to 40–500 p.p.m., with a manganese content to about 2 p.p.m.

The Tygarts River at Elkins became so dry that it was necessary to curtail the pumping to 3 to 4 hours a day and in the emergency additional water was hauled. Finally a pipe line was laid from the Cheat River over a mountain and the pumped water allowed to flow down the other side into a tributary of the Tygarts and thence to Elkins, a distance of some twelve miles.

The large water power storage reservoir in Cheat River (capacity 73,000 acre feet) was drained completely under the direction of the Army Engineer in charge of the Monongahela River Basin. This water alone kept up the navigation on the Monongahela between Point Marion, Pennsylvania and Pittsburgh, and provided water for industrial and sanitary use around Pittsburgh. In the meanwhile the Army Engineer had drained, by arrangements, the Monongahela pool at Morgantown completely dry, a direct menace to public health there, since the sewage discharged into the dry river bed remained there within the city.

Charleston derives its water supply from the Elk River about a mile above its mouth. The flow in the Elk being about one-third the consumption, the water backed up out of the Kanawha River pool formed by the Government locks. The flow carried with it the major portion of Charleston's sewage. Although bacteriologically safe, extreme conditions of taste and odor in the filtered and chlorinated water prevailed. R. E. Tarbett of the U. S. Public Health Service declared it an unprecedented situation in considering all of its phases. All known methods of treatment were tried but to no avail. An emergency pipe line was laid to the Kanawha to bring in a less polluted supply. Coincident with this trouble an epidemic of mild intestinal trouble developed throughout the city, about 15,000 people being affected in November. Dr. Veldee of the U. S. Public Health Service investigated the epidemic, but did not directly blame the water supply.

Other towns were forced to dig additional wells or haul their water by rail, such as Spencer, Terra Alta, and Harrisville. Terra Alta was the site of a severe outbreak of typhoid fever, due to lack of proper precautions in the use of a supplementary water supply.

The low water condition in the Ohio River caused the hardness of the water to increase at Wheeling to 180 p.p.m. in the latter part of August, which is about three times the normal.

INDUSTRY

Certain industries in West Virginia were badly crippled by a lack of an adequate supply of water. At Richwood the Cherry River became dry forcing a large paper mill, a large tannery and a large clothespin factory to close early in June. This condition prevailed until the first part of December.

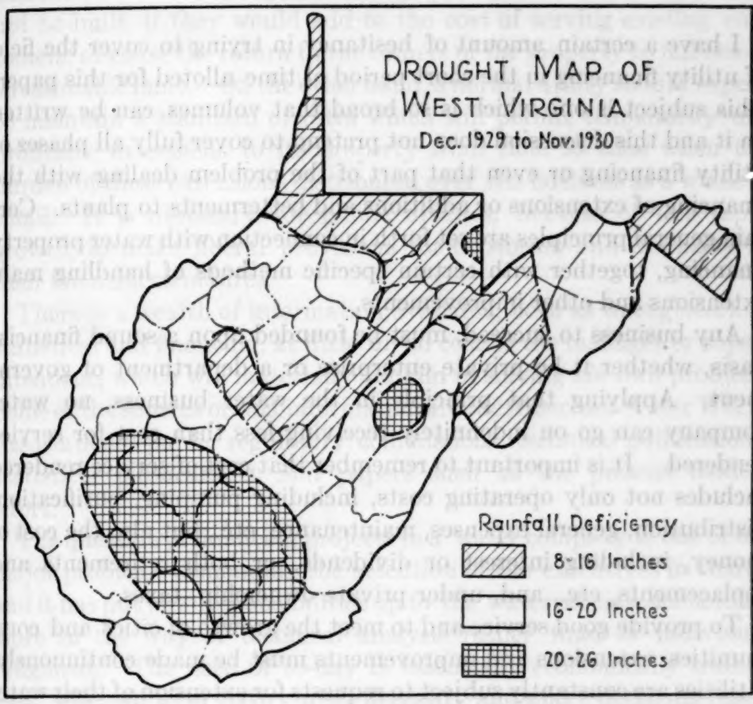

FIG. 3

Two large tanneries on the Greenbrier River were forced to close down early in July due to inadequate stream flow and were still closed late in December.

The railroads had to haul water in several places for their own use.

In several small towns it was necessary to cut off the industries in order to have water for the minimum requirements.

PROBLEMS OF WATER UTILITY FINANCE[1]

By A. P. Michaels[2]

I have a certain amount of hesitancy in trying to cover the field of utility financing in the short period of time alloted for this paper. This subject is one which is so broad that volumes can be written on it and this discussion does not pretend to cover fully all phases of utility financing or even that part of the problem dealing with the financing of extensions or additions and betterments to plants. Certain general principles are set forth in connection with water property financing, together with certain specific methods of handling main extensions and other improvements.

Any business to succeed, must be founded upon a sound financial basis, whether it be private enterprise or a department of government. Applying that principle in the water business, no water company can go on indefinitely receiving less than cost for service rendered. It is important to remember that cost of service rendered includes not only operating costs, including pumping, purification, distribution, general expenses, maintenance, etc., but also the cost of money, including interest or dividends, or both retirements and replacements, etc., and, under private ownership, taxes.

To provide good service and to meet the growth of cities and communities, extensions and improvements must be made continuously. Utilities are constantly subject to requests for extension of their water mains and often in sparsely settled territory. Some of these extensions are logically required to take care of the steady growth and expansion of the communities, whereas others are remotely located and unrelated to community development. It should be pointed out that public utilities assume an obligation to render adequate service within the territory reasonably accessible to their facilities. This does not mean that only those patrons who are immediately adjacent to existing lines are entitled to service, but these lines must be

[1] Presented before the St. Louis Convention, June 8, 1930.

[2] General Manager, Utilities Commission, Orlando, Fla.

extended for reasonable distances in keeping with community expansion.

The problem, therefore, centers around a definition of what constitutes a reasonable expenditure for extensions. Long and expensive extensions serving only a few people, which are of no benefit to the community as a whole and which for a long time do not yield sufficient revenue to cover the full cost of the service should ordinarily not be built, if they would add to the cost of serving existing customers, or cause the return to the owners of the property to fall below a reasonable limit. On the other hand, a normal utility should expect to maintain a standard of rates which will permit temporarily unprofitable extensions to its property from time to time when the burden of these extensions distributed over the business as a whole is small. It is necessary for public utilities, because of this rapid growth, to make liberal provisions for expansion and flexibility in their financial structures.

There is a wealth of information available, both as to engineering, statistical and financing, at little or no cost to the manager or superintendent, which will materially aid him in solving his own problem. Some of the sources of this information are the American Water Works Associations, public regulatory commissions, technical publications, statistical publications, and papers such as the present modest effort.

The question of financing projects in a water company is one of the major problems demanding the attention of the executives in charge and it has put new responsibilities up to the water officials demanding more in the way of technical analysis rather than of individual judgment. The need of to-day is essentially economically trained men, who can weld theory with necessity and make decisions based on careful analysis of the practical problem in process of solution. Whether a utility plant is successful or not depends in a very large measure upon the ability of its executives and officials to solve the problems confronting them. In modern operations the policy of the management should determine the relation of investments to annual earnings, gross revenues, net revenues, etc., called investment ratios, which can serve as a guide, and from these ratios and policies the limits beyond which it is unsafe to go can be determined.

If the net income on the investment has been satisfactory in the past, the ideal situation is to plan extensions so that increased revenue and expenses due to extensions are in the same ratio to the additional

investment as the ratio that had resulted profitably before. Obviously ideal conditions are impossible but the ideal may be approached by following definite policies. In working out any financial problem a budget is the first step in the right direction. The steady growth in size of business concerns has gradually changed the control of the activities from a personal to a statistical basis. Predictions and plans based upon statistical forecasts have proven of dollars and cents value under actual trial. They have served to avoid loss and have allowed correlation of activities through planning to a degree hitherto unknown. A budget is sometimes known as a bogey, a plan, a program, prospectus, or estimate. It is used here to mean an estimate of the financial requirements and resources for any given period of time (usually one year) made in advance. It should include the following items: estimated gross revenue, estimated operating expenses, net earnings, interest and dividend requirements in two ways: (1) on a cash basis and (2) on an accrual basis. It should also include the estimated amount of capital improvement for the year and should show the funds available at the beginning of the year and those available for this purpose from the following sources: contributions from customers, ordinary operations and the issuance of securities, and kind of securities to be issued.

The budget is made up in the same manner that a construction project is estimated, and unforseen or contingent items should be provided for. So far as possible the budget should be set up on a monthly basis so that as the year progresses, one can foresee difficulties arising through over or underestimating.

An executive of a public utility has a right to know that the money upon which an extension is predicated is either in hand or that very reasonable assurance is given that it will be on hand when needed. It generally produces an unpleasant situation to start a construction project and before it is completed have something occur, which makes it necessary to abandon the project because the finances are not forthcoming.

Plans for the projects should be in such a shape that advantage may be taken of market conditions and price fluctuation in the material and labor market. It is profitable to study of curves for labor wage, price of money, price trend of commodities and such other barometers as are published by statistical departments. To illustrate, the writer recalls an instance of a large electric company which had all of its projects planned and filed, so that when the price of

copper dropped from 22 to 13 cents per pound, construction work was immediately started, with the resultant investment of approximately two-thirds of what it would have been if advantage had not been taken of the market conditions.

CLASSIFICATION OF ADDITIONS AND BETTERMENTS

Let us attempt a classification of additions and betterments on the basis of the manner in which they will be financed. The outline appears as follows:

I. Extensions usually requiring issuance of bonds:

1. New pumping plant
2. New large sized pumping equipment
3. Installation of large transmission mains
4. Development of new or additional water supply
5. Other similar items

II. Extensions which usually are in class I, but which in some cases may be financed by notes or warrants without bond issue. Such financing is usually for short terms and must be replaced eventually by longer term issues of bonds.

III. Extensions financed temporarily or permanently in some other manner usually consisting of:

1. Distribution mains
2. Hydrants
3. Services
4. Meters

IV. Extensions of distribution or services financed by contributions from the consumer.

In handling extensions that would properly come in the first group, the municipalities, generally speaking, have the authority under the several acts of different states under which they can issue bonds, and these limitations need not be considered here as they are very ably set forth in Chapter 23 of Water Works Practice, subject, however, to the restrictions of their own charters.

In considering the second group there are certain municipalities which have the power to issue notes to cover their financing of extensions that can be classed as major extensions and of necessity would be subordinate to those under Classification I. This borrowing power is in general limited to 10 percent of the fixed asset value of the properties, and this amount plus the monies, which are in the

funds constituting the reserve funds (such as depreciation, amortization, etc.) can finance extensions of some magnitude. These of necessity should be short term notes and should not be financed over long periods of time.

In financing additions and betterments in the third class, that is, those extensions which are being made constantly to extend service to new consumers, various methods are in use, some of which are, as follows:

(1) Direct appropriations from the general funds of the municipality.
(2) Special assessments against property owners or a special tax for the purpose.
(3) Sale of municipal bonds not directly a mortgage on the water property.
(4) Out of surplus earnings of the water department.
(5) Out of reserve funds.
(The sixth method will be discussed separately and becomes our fourth general classification of financing contributions from consumers.)

A working surplus of available cash sufficient to meet current operating expenses and extensions must be maintained, and the budget is the only method of constantly maintaining funds for such purposes.

In approaching the fourth general method, or classification, of financing extensions, which is those financed through contributions we find that it is only equitable to work out some special method whereby those who wish service, where no distribution main is available and the revenue from the service is not in the normal ratio to the investment, may receive the extension. In working out such a theory, some extensions are made in outlying territory where there are no mains at that time and which are logically required to take care of normal growth of the city.

In principle, however, all extensions of service or mains should be made on a basis to provide a proper rate of return on investment within twelve months time, that is, after applying normal operating expenses to the anticipated revenue. If it is found that the extensions are long and expensive and serve only a few consumers, and are remotely located and unrelated to the community's development and which for a long time will not yield sufficient revenue to cover the cost of the service, and would add to the cost of serving the existing

consumers, then it is proper and equitable to expect the benefited parties to carry this investment at least until such a time as it will not prove a burden upon the existing customers.

POLICIES OF MAIN EXTENSIONS

The public service commissions of various states have adopted a policy of dealing with each case on its individual merits, but some of the Commissions have gone further.

The Public Service Commission of California has stated "The revenues from the sale of water for 12 consecutive months must equal 25 percent of the cost of the extension and of the services and meters attached thereto."

Some companies in Pennsylvania have adopted a policy of requiring 50 percent of the cost of the extension to be deposited, which would be later refunded under certain conditions.

Some privately owned companies in other states require a cash settlement with a provision for either a partial or complete refunding based on the development of the business along the extension.

The New Jersey Commission has laid down a general rule outlining the conditions under which the water companies can make extensions and says: "In the case of a real estate development the full cost shall be advanced or loaned by the real estate promotor, and shall later be reimbursed by the water company at the rate of \$3.50 for each \$1.00 annual gross revenue. If the property to be supplied is already occupied, the amount shall be the cost of the extension less \$3.50 for each \$1.00 of immediate revenue, the balance to be returned at the same ratio as additional consumers take service from the extension." The New Jersey Commission has gone so far as to say that a water company should not depart from this rule.

The policy adopted by the Orlando Utilities Commission of Orlando, Florida, is, to use 2-inch galvanized iron pipe to develop certain sections of the city, and when this development has reached the stage where it will support the investment of a 6-inch or larger cast iron main, the 2-inch pipe is removed and placed in stores to be reused in other developments. If the real estate promotor desires fire hydrants the cost is estimated on the basis of a 6-inch or larger cast iron pipe.

The system followed in this connection is as follows: Either a prospective consumer or the subdivision promotor comes into the office to make application for either a service at a definite locality or

for furnishing a supply of water for the subdivision or new section to be developed. A ready reference is made to the water pipe map which reveals whether the present service lines are within reasonable distance of the prospective customer or subdivision, and if the pipe is located within 100-feet of the prospective customer the service is put in at the expense of the Orlando Utilities Commission. If it is found to be greater than 100-feet, an order is given by the Contract Department to the Engineering Department setting forth definitely the kind of service desired and the location, with a request that an estimate be made showing the location and length of pipe and the number of services that can be served from this extension, from which map the Contract Department is able to estimate the annual gross revenue likely to be derived from such extension. This particular district is then canvassed by the Contract Department and, if sufficient, the application is signed to indicate that the annual gross revenue derived from this investment will amount to $33\frac{1}{3}$ percent of the total cost, the Orlando Utilities Commission makes the investment without any cost to the consumers. If it is found that the consumers will not yield an annual gross revenue of one-third the total cost, the interested party or parties are asked to deposit with the Orlando Utilities Commission the entire cost of the installation interest) until such a time as the annual gross revenue amounts to one-third its cost. This deposit is then covered by a formal agreement setting forth specifically the location, and size of the pipe, and the entire cost, with a provision stating that, whatever the annual gross revenue amounts to one-third its cost, the entire amounts will be refunded. It naturally follows that the customer or the account will receive credit for the revenue derived from any and all subsequent connections made directly on this extension covered by this agreement.

This plan has worked well in connection with the development of new sections, subdivisions, etc., where the developers wished to have electric and water service installed for the improvement of their properties without knowing the amount of building contemplated and the Utilities not having any assurance of future income, could not afford to invest its own capital. Under this plan the actual work of construction is done by the Utilities and the extension becomes a part of the property of the Utilities; the deposit agreement becomes a liability of the Commission and is so reflected on the books. This arrangement also applies in the case of special service connections

where it is necessary to rebuild and increase load capacity, in order to take care of extraordinary demands.

In five years the Orlando Utilities Commission has made extensions on this plan aggregating $165,000.00, about $100,000.00 of which has been returned to depositors, the extensions made having become self-supporting and producing sufficient revenue to justify full ownership. There are agreements still in force of long standing upon which the Commission has been collecting some revenue, and has been obliged to service and maintain these lines. The consuming properties have not developed sufficiently to warrant a refund of the deposits.

When a deposit is made and a refund agreement entered into, a subsidiary ledger account is opened upon which all the services of that section of line are listed, and the billings for each service are posted monthly. It is, therefore, possible to determine at a glance the condition of each deposit made with reference to refund possibilities, adequate cash reserves being maintained to provide for such refunds when due.

DISCUSSION

E. W. Agar:[3] Among the many helpful suggestions on financing water utilities mentioned in Mr. Michaels' paper is, "Any business to succeed, must be founded upon a *sound financial basis,* whether it be a private enterprise or a department of government." The government of the United States has been in existence nearly one hundred and fifty years. I venture an opinion that over 50 percent of the existing water plants are approaching the period when they must be rehabilitated and new and better extensions should be made. What about the funds for these purposes? I can hear many water works officials saying, "The depreciation fund for such much needed work is lacking," thus proving the position that the business of managing water plants in the past was a failure for not having established this sound financial basis. With municipalities owning and operating their water plants, the management, for political purposes, often capitalize the fact that the water department has, under low rates, not only paid the operating cost, but contributed to the upkeep of other city departments, having no concern for the physical condition of the plants and establishing in the minds of the voters a false economy and creating a burden upon future generations of the cost of practically building a new water system. Many states have

[3] Superintendent, Water Department, Valparaiso, Indiana.

allowed such financial conditions to exist because there are no laws to protect municipal water funds from being exploited for all kinds of city purposes, including the possibility of frequent changing of water plant officials to provide positions for incompetent ward healers and their friends to the detriment of the city's most important public utility.

Mr. Michaels has well said that to provide good service and to meet the growth of cities and communities, extensions and improvements should be made continuously. I wish to commend him for the valuable information he has given as to how such extensions and improvements are made in many communities under the directions of public service commissions, and water plant officials. I am in sympathy with the thought that the income of a water plant should be sufficient to provide first class service for the consumers, establish a depreciation fund to make good depreciation, and create revenue enough to keep one step in advance of private enterprises, in the extensions of water mains to aid in the developing of growing territory. Then add to this that city officials must protect water revenues for such purposes and not dissipate such funds by transferring them to the general fund of the city.

I am not in sympathy with the thought of investing funds, private or public, in "wild cat" real estate development requiring the extension of new water mains. Failure often follows such ventures resulting in the investing of water funds when real estate agents, with good intentions, cannot "make good," under some of the plans suggested by Mr. Michaels' discussions. In questionable real estate developments, I would urge that the promoter pay the total cost of water main extensions, and when the income is sufficient to pay the cost, after a proper accounting, including cost and interest on investment in such extensions, and interest on net income from water consumers under a proper city ordinance, the utility can then purchase the main extensions as a safe investment. Such extensions should be installed under the supervision of the water works officials, so that when purchased they would "fit in" with the whole distribution system. There is much merit under all the plans mentioned by Mr. Michaels and especially the Orlando Method, and I would help the real promoter with public funds in developing assured growing territory, but would guard jealously utility revenues in financing main extensions in new territory that may require many years to develop.

In discussing extensions under the four plans of financing as set

forth in the paper under consideration, I favor number one, namely "Extensions usually requiring issuance of bonds." The other plans, in my opinion, involve too much confusion, requiring accounting and unnecessary expense. Plan No. 1, under proper state and city laws, can be made to include, in a large measure, the best features of the other three. Call it if you please, the "Valparaiso Plan." I am satisfied that Mr. Michaels' "budget plan" in connection with financing water works improvements, is quite complete and should be adopted and then followed out in every detail. The plan of improvements, including rehabilitation and extensions, should be made to cover as many years in advance (based upon good engineering advice) as possible so that advantages of money, labor and material markets can be taken to serve the water consumers to their best interests.

In the case of worn out municipal water plants, when an adequate depreciation fund has not been established to rehabilitate the property, the first requisite is a state law to provide city councils with the authority and power to produce revenues for an operation and maintenance fund, a depreciation and main extension fund, and a bond and interest redemption fund, under reasonable water rates. The management of the plant in securing and expending water funds should be carefully guarded by a state public service commission. This law should provide that, while the water bonds to be redeemed from the revenues of the water department (not by property tax) are outstanding and unpaid, the complete management of the water plant should be placed with a board of trustees made up of at least five members, the mayor and one alderman of the city council to be exofficio members of this board and three citizens of outstanding reputation for integrity, responsibility and business ability to be appointed by the mayor, with the approval of the city council, as the appointive members. The citizens so appointed should serve as follows: one member for one year, one for two years and one for three years when first appointed, and afterwards, each year, a member to be appointed for three years, thus providing a continuous board of experienced managers. The law should also provide that, under a proper city ordinance, bonds can be printed in amounts to provide funds for main extensions and other new improvements and sold from time to time as money is needed to make these additions at the most advantageous times.

To secure the holders of water revenue bonds all contracts involving expenditures of borrowed money should be approved by a public ser-

vice commission, thus assuring the money lenders that these funds are to be used in the making of new and permanent improvements, adding to the value of the water works property. Before such revenue bonds are sold the public service commission should certify that the income and revenue of the water works, in addition to providing for operation and maintenance and depreciation, are sufficient to pay the principal and interest of the bonds that may be sold. Such bonds should not be an indebtedness of the civil city calling for redemption by a city tax on real and personal property. If possible, the revenues of the water works should be sufficient for all cost of operation, maintenance and extensions of every kind. Then these revenues are expended and protected as herein indicated. This law should also provide that water revenues can be used legally only for water plant operation and maintenance, water works improvements, and retirement of water revenue bonds.

Time will not permit further details, but this plan of financing and management, as outlined in a general way, provides the safest and best management of municipally owned water plants, the financing of water mains extensions and other new improvements at the lowest possible cost, by securing funds when the money market is easy, by providing the proper protection due the bond holders, and by reducing bad politics to a minimum.

Another aid in securing finances for water works purposes is to have laws to require all users of water to pay the established rates; civil cities for fire hydrants, fire departments, street sprinkling, flushing of sewers, etc.; all schools, public institutions, churches and businesses together with provisions for collecting such rates. This is fair and economically right to water consumers and property tax payers alike. Under such laws and ordinances the management of water works "can play no favorites" and should have no financial embarrassments.

FERRIC IRON COAGULATION[1]

By Alexander Potter[2] and Wm. I. Klein[3]

Successful results of experimental runs upon a water resistant to ordinary methods of purification has led to a continuance of the use of ferric iron at Mamaroneck, N. Y.

This plant, recently constructed for the Westchester Joint Water Works No. 1, serves the Towns of Harrison and Mamaroneck, the Villages of Mamaroneck and Pelham and portions of Rye and New Rochelle in Westchester County, New York.

FEATURES CONTROLLING DESIGN

The design of the new filter plant was controlled by definite and more or less exacting conditions.

The construction of the new plant was made as an improvement to an existing plant. The distributing system was without storage reserve. Therefore, all changes, additions and betterments had to be made without shut down or stoppage of the pumps.

All new work had to be incorporated as part of the existing plant using such space as was available within the building, including space utilized by the pressure filter. The pressure filters of the old plant had to be maintained in service until replaced by the new, following this they had to be removed and the building housing them converted into a two story chemical house. The new filters, filter house and settling basin had to be constructed on an irregularly shaped, steep rock outcrop of limited area, all that was available around this old pumping station.

The Mamaroneck River water was known to be difficult to treat. This stream, derived from a small water-shed, without impounding reservoirs represented practically a straight runoff, hence flashy, with rapid variations in chemical characteristics, color, turbidity,

[1] Presented before the Water Purification Division, the St. Louis Convention, June 5, 1931.

[2] Consulting Engineer, New York, N. Y.

[3] Consulting Engineer, New York, N. Y.

odor and taste. Its pH value is erratic; in general it is a soft, aggressive water, containing iron and manganese and possessed of a color or stain resistant to chemical treatment. Two impounding dams now under construction on the water shed will modify and correct these difficulties to a considerable extent.

The capacity of the filter plant is 5 m.g.d. with provision for expansion to an ultimate capacity of 10 m.g.d. All references that follow relative to retention periods are based on this 5 m.g.d. rate.

This watershed some 8.75 miles long with a total gathering extent of 14.46 square miles is taxed to its limit to furnish this yield. This high yield, however, is based upon deficiency of stream flow during dry periods being compensated by diversion from New York City's reserve storage in Rye Lake (Kensico Reservoir).

These factors are responsible for a design of plant of wide elasticity in operation with provision for variations in chemical treatment and application.

WATER TREATMENT PLANT

The water derived from the Mamaroneck River flows by gravity from the old dam just west of the new filter plant, through a 30-inch cast iron main to the electrically driven low lift centrifugal pumps, the battery of low lift pumps consisting of three units each capable of pumping 3 m.g.d. against a 25 foot head.

On its way to the low lift pump the water passes the chemical house wherein provision is made for chlorination either as super or prechlorination to the raw water or for chlorination of the final effluent. Likewise means have been provided for the use of practically any form of known coagulant to raw water, and for any alkaline corrective treatment that may be required by either the raw or filtered water. This equipment in its entirety is within a chemical house provided with a hydraulic lift, with an upper chamber of large storage capacity, and with floor hoppers of the closed welded metal type for gravity flow to the dry feed chemical machines located directly underneath. All apparatus is in duplicate, dry feed machines are provided with dissolving hoppers and eductors to convey the chemical solution against head to the points of application. For emergency use one portable electrical dry feed machine is provided for application of chemicals at any point in the process of water treatment that may be desired.

Passing from the low lift pump the water is forced into either

the mixing chamber, primary sedimentation basin of Dorr Clarifier type, or secondary sedimentation basins. The mixing chambers are two concrete tanks placed within the filter building in line with the filters. Each mixer is supplied by an underflow baffle from a central entrance chamber, provided with a hydraulic automatic control valve that maintains a fixed elevation of water in these mixers. Each mixer is provided with a 12-foot diameter concrete throat in its center, wherein a motor driven Dorr impellor agitator revolves. The water previously treated with coagulant enters at the bottom of the mixers, is agitated vertically by the impellor, as it crosses and finally reaches the opposite side of each mixer where it decants through an upper level port either into the Dorr clarifier or the secondary subsiding basins. These mixers are designed for an ultimate retention of twenty minutes. This apparatus is efficient; its action is beneficial in formation of mass floc; compact; operating without any appreciable loss of head; all of which are valuable and suitable adjuncts in the treatment of this water.

For primary subsidence a 60-foot rectangular Dorr clarifier with capacity equal to one hour retention is utilized. Limitation of available space restricted the total settling period to three hours. Therefore, a basin of this type (with its self-cleaning feature without interruption to service) is peculiarly applicable.

Sludge from the clarifier can flow by gravity to the sludge filters or by a sludge pump be recirculated to the mixer where a proportioning device feeds part or all of this sludge either into the mixing chambers or into the sewer.

Recirculation of certain types of sludge has demonstrated that this process has merit. Its action induces mass floc formation that settles out quickly with only moderate increases in the chemical doses.

For secondary subsidence there are two covered concrete tanks, having a combined capacity equivalent to two hours, which used in conjunction with the Dorr basin furnishes a combined retention period, after mixing, of three hours, all that could be provided within the limited area available.

The filters consist of 4 filter units each of 1.25 m.g.d. capacity; with tank construction of reinforced concrete on rock foundation. The filter units have a central flume with cast iron circular wash water collecting gutters, 27 inches depth of filtering sands superimposed on 16 inches of graded gravel.

The underdrain system in each filter unit consists of two cast iron

elliptical manifolds with brass laterals, 2 inches in diameter, and umbrella type strainers equipped with air trap tubes. The beds are washed by utilization of the air and water wash. Before applying wash water, the bed, as a preliminary to the washing process, is drained down to 8 inches below the gutter lip, then agitated with air for a period of about 3 minutes, following which the wash water at a 15-inch vertical rise per minute is applied. Each filter is equipped with an effluent controller arranged to slow down automatically at times of high water in the clear water basin. Marble operating tables are provided for each unit equipped with indicating loss of head gauge and control valves for operation of hydraulic valves and sluice gates.

The effluent from each filter passes into a collecting flume directly under the pipe gallery, from which it rises through an illuminated sight or detector well to the influent flume of the aerator. This sight well is 4 feet by 4 feet white tile lined bottom and sides. The depth of filtered water visible is 10 feet and the illuminant a high power daylight electric lamp. This detector sight well is extremely delicate in operation; it shows the slightest passing of color, turbidity or hydrate. Its particular merit is that it has all hands busy correcting any operating troubles before they become serious enough to impair the quality of water delivered to the distribution system.

The filtered effluent then passes over an open non-freezing type riffle plate aerator, thence into the clear water basin from which by either of three high lift DeLaval electric driven centrifugal pumps having a total capacity of 8 m.g.d. against 300 foot head), the water is pumped into the distribution system, now provided with a 600,000 gallon storage elevated tank reservoir for smoothing out peak demands and as a stand-by to the distribution system.

Waste water from the filters and the settling basins is passed to a sludge filter to prevent fouling of the stream below the plant by sludge deposits.

For reliability and economy of operation a Diesel engine driven generating plant was installed in duplicate.

OPERATION

The new filtration plant was started during the last week of February, 1929, operating with sulphate of alumina as the coagulant, preceded by chlorination. Prechlorination in conjunction with this coagulant was essential at all times to insure complete color removal.

The optimum coagulation was found to be variable, but always within a narrow pH range, necessitating daily laboratory determination for guidance of plant operation.

Vigilant care was required to prevent over or under dosing, both resulting in unsatisfactory or pin point floc formation, colloidal in character. Excellent heavy floc formation was at all times obtainable using soda ash or hydrated lime previous to the application of sulphate of alumina, but their use intensified and set the color. Correction for aggressiveness was possible only after filtration. Applying corrective alkaline chemicals at any point before filtration would result in intensified and fixed color.

Aeration is of material benefit in removal of taste, odor and CO_2, with the consequent saving in amount of corrective chemical treatment after filtration.

With warm weather during the 1929 season came the drought. Low stream flow and algae troubles with intensified taste and odor in the raw water caused filter operating difficulties.

Control of algae by copper sulphate treatment of the stream, likewise the continuous feeding of this chemical mixed with granulated sulphate of alumina through the dry feed machines, proved ineffective. The algae were found to be resistant to any control by use of copper sulphate. Instead of abating it increased. Slime algae grew on the sand in the filters causing sand shrinkage, cracking, mud balls and short, irregular filter runs. Super prechlorination with potassium permanganate treatment controlled the algae growth, cleaned up the filter sand, stopped the shrinkage and cracking and eliminated the taste and odor.

The chlorine absorption of the water was both variable and quite high but was successfully controlled by operating on a fixed residual chlorine of 0.5 p.p.m. in the Dorr effluent. This provided an effluent free from gas formation and with safe bacterial counts. Summer was well advanced, however, before we could secure more than the necessary residual chlorine in the filter effluent; the heavy chlorine dose was consumed by oxidation in the sand beds.

When the residual chlorine began to increase in the filter effluent, the trouble was over, the beds were free of organic matter and the chlorine dose was reduced accordingly.

Potassium permanganate was applied by mixing it with the sulphate of alumina, apportioning a definite amount and mixing it with each bag of coagulant before it was dumped into the hopper of the dry chemical feeders.

The dose of potassium permanganate to start with was 0.2 p.p.m., increasing in amount with the intensity of taste and odor, until during the peak the dose reached a maximum of 0.45 p.p.m. for a short period, this dosage being reduced as the taste and odor in the raw water abated.

The plan of treatment as outlined continued during and following the dry period, delivering a satisfactory effluent, but accompanied by rigorous, vigilant watching and correcting of chemical dosage until January, 1930, when the river froze over and the raw water temperature dropped close to the freezing point. With this drop in temperature it became impossible to coagulate this water, except by the use of hydrated lime applied previous to the sulphate of alumina. Excellent floc formation was obtained, but the filtered effluent had a fixed stain and lime started to deposit on the sand of the filter beds.

USE OF FERRIC IRON

At this time and under such conditions a plant scale experiment was made using ferric iron as a coagulant. The results were so satisfactory and far reaching in their benefits to the plant as a whole, with incident ease of control and operation that what was started only as an experiment has continued as routine plant operation.

Plant control, using ferric iron coagulant, is based upon two simple tests made by the filter attendant at the mixing chambers, as follows:

1. Observation of the character of floc formed, using a floc detector. The operator's eye is quickly trained to tell the difference between good and improper floc formation. If there is any question as to whether the water has secured proper treatment, filtering 50 to 100 cc. through filter paper and noting color of resulting effluent is a quick and ready check. The sampling point for these determinations is at the effluent side of the mixing chambers or twenty minutes after the chemical dosage.

2. Determination of residual chlorine in water sampled from the influent side of the mixer where approximately 0.2 p.p.m. of residual chlorine, or higher, is maintained as may be required for control of algae growths, tastes or odors.

This last test is within a five minute period following application of the chemicals. It insures sufficient chlorine to react with all the iron, thereby preventing free iron from passing into the basins and also compensates for the variation in chlorine absorption of the raw water.

In so far as we have been able to determine from the action so far encountered on this water the best coagulating results are obtained by:

a. Preparation of the coagulant made with close regulation of chlorine in an amount not to exceed by more than 10 percent the theoretical requirements.

b. Prechlorination of raw water to an amount sufficient to secure a residual chlorine of approximately 0.2 p.p.m.

c. The application of chlorine for prechlorination made separate from the application of the chlorine for the purpose of preparing the coagulant.

d. The coagulant is applied to prechlorinated water.

e. Anhydrous ammonia is applied to remove and prevent any chlorinous taste or odor. Anhydrous ammonia is applied to the filter effluent.

Under such control the operators have produced and are maintaining a sparkling, brilliant, plant effluent free from any taste or odor, with considerable ease of operation, especially so when contrasted with the use of sulphate of alumina as the coagulant on this plant.

The actions of these two coagulants, on this particular water, compare, as follows:

Sulphate of alumina	*Ferric iron*
Low temperature of water prevented floc formation, unless hydrated lime is used, resulting in set of yellow color in effluent and lime deposits on the sand beds.	Temperature of the water has no effect on floc formation even under the coldest condition of water with stream frozen over.
Good floc formation is only within a narrow pH range.	During period of operation raw water has varied from a pH of 6.0 to 7.6 without any apparent action detrimental to or in favor of floc formation.
Over and under-dosing causes pin point floc formation of colloidal character that would not settle out in the available settling period.	Under-dosing will not throw down all color, and effluent will show stain and lack of brilliancy.
Color and hydrate pass filter resulting in clouded effluent.	Over-dosing has no deleterious action other than extravagant use of chemicals causing a heavier and more rapidly settling floc than is required. It shortens filter runs without impairment of quality or brilliancy of filter effluent.

Sulphate of alumina	*Ferric iron*
The floc formed is very light and buoyant. The retention period available is not sufficient to cause efficient settling. Floc passes over on and blankets the filter beds, causing short runs. Floc on filters so dense that wash water gutters are not visible through 3 feet of water.	Floc formed is heavy, settling quickly in the available basins. Small amounts of floc come over on filter beds, runs are lengthened and water while flocked sufficiently to produce brilliant effluent is clear so that not only the wash water gutters but the surface of the sand bed is clearly visible.
Slightest variation in water level in settling basins stirred them up and brought heavy floc over on filter beds.	Variation in water level in settling basins as great as 3 feet does not stir them up or cause heavy floc to come upon the filters.
Three hours settling period, followed by filtration period, successfully handles flood conditions, but due to characteristics of floc formation the filters carry a heavy burden that materially shortens the run period.	Turbidity increases weight of floc and rate of subsidence. Four floods have so far occurred, since use of ferric iron coagulant. The character of effluents from the Dorr basin has remained clear. So far flood turbidity has been controlled within a thirty-minute settling period without any material increase of filter load.
The light feathery floc of this coagulant formed a dense mat upon the sand beds, causing trouble from air binding of filters and shortened runs. Irregularity of flow caused release of accumulated air entrained in the gravel and lower sand layer, which bursting up through the beds destroyed their efficiency and allowed color and hydrate to pass through.	This trouble was eliminated within 48 hours following use of this coagulant at the plant.
Impossible to retard flow or stop filter, without passing color and hydrate. When necessary, filters had to be taken completely out of service, washed and filtered to waste for 30 minutes before effluent was safe to turn into filtered water basin.	Use of ferric iron corrected this difficulty at once. Filters can now be shut down at any part of the run without damage from release of entrained air and started up without washing or filtering to waste, delivering a brilliant water at all times. Since use of this coagulant we can operate intermittently by closing entire plant down from midnight to 4 A.M., during which period water is pumped from clear water basin storage.

Sulphate of alumina	*Ferric iron*
With alum coagulant, despite the self-cleaning apparatus of the Dorr, due to lightness of floc and its accompanying slow settling characteristic, it has been necessary to clean the secondary settling basins monthly, due to the accumulation, during this period of time, of about an 8-foot depth of sludge.	**With use of ferric iron the same procedure of cleaning secondary settling basins each month has been adhered to, but the accumulated ludge is only 2-feet in depth. This is due to increased settling action in the Dorr occasioned by the heavier floc formation of the ferric iron.**
Sand grains are coated with gelatinous films of alumina hydrate with all its accompanying filter operating troubles.	**Sand is free from all gelatinous film and as clean as fresh new sand.**

WATER LEVEL INDICATION BY TELEPHONE[1]

By Dewey M. Radcliffe[2]

The water elevations of the filtered water reservoirs of the Washington, D. C., water supply are plumbed in a modern and novel manner. An automatic level indicator is located on each reservoir which by means of a standard "Bell System" subscriber's station will transmit the water level to any telephone connected on the system.

In a small building on the site of each of three reservoirs in widely separated sections of the city, a complete water level indicator and transmitter, dubbed the "electrical man," with all of its equipment is installed.

It consists chiefly of three main parts: a relay operated by telephone ringing current, furnished by the telephone company; a cabinet, housing miscellaneous relays and selector switches, attached to the front of which is an ordinary desk type telephone instrument and a swinging arm supporting a small loud speaker directly in front of the telephone transmitter; a float operated selector switch connected by a multi-conductor cable, with the housing cabinet.

The devices were developed to furnish information concerning the level of water in the reservoirs in the most efficient and economical manner. Other types of indicators were studied but eliminated, due to the long distances between reservoirs and filter plant and pumping stations; also the high cost of line construction or line leasing cost. This led the engineers to select a device which would operate over the standard telephone, at regular subscriber's monthly rate, and insure twenty-four hours reliable service per day. This type of indicator allows any official of the water supply system to check the condition of the reservoirs from any point.

The indicator does not interfere in any way with the electrical operation of the telephone circuit, as only sound is transmitted, and no electrical connections are made to the telephone circuit, thereby overcoming all objections set forth by the telephone company.

[1] Presented before the St. Louis Convention, June 5, 1930.

[2] Associate Engineer, U. S. Corps of Engineers, Washington, D. C.

The automatic operation is started by giving a stated telephone number to the operator, who rings the number called, causing the relay in the transmitter house or reservoir site to operate, thus energizing the various relays and switches of the transmitter. These cause an electro-magnetic device, in the form of an arm coming through a small aperture in the housing cabinet, to lift the receiver and hook of the telephone and hold the receiver in off-hook position until the signal has been transmitted, after which the magnet is de-energized and the receiver is returned to normal on-hook position. The indicator operates equally well on the dial telephone system. In this case the telephone number of the indicator is dialed in the usual way.

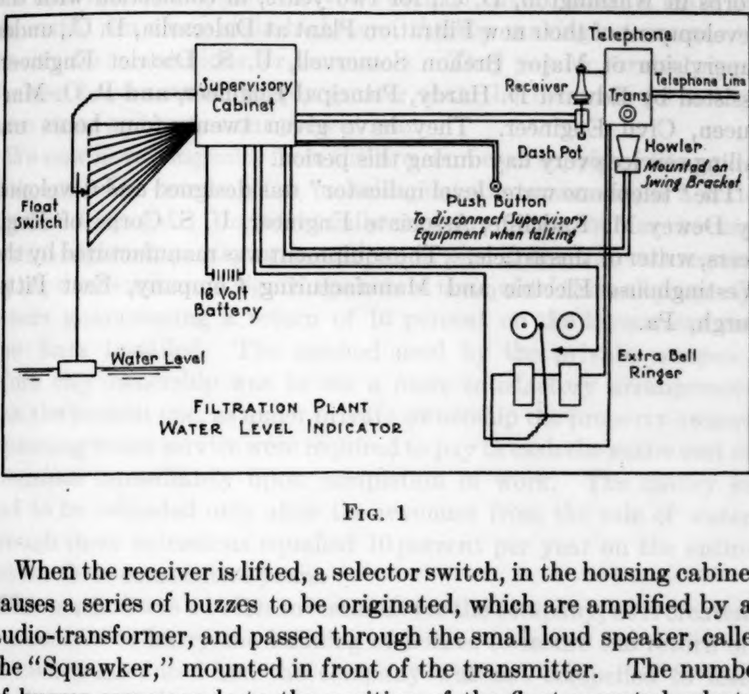

FIG. 1

When the receiver is lifted, a selector switch, in the housing cabinet, causes a series of buzzes to be originated, which are amplified by an audio-transformer, and passed through the small loud speaker, called the "Squawker," mounted in front of the transmitter. The number of buzzes corresponds to the position of the float-operated selector switch, in this case, the depth of the water in feet, contained in the reservoir. The signal is repeated so that the party receiving the indication, can confirm the original report, after which the receiver is restored to normal, as mentioned above, and the complete mechanism is in position to record the next call.

The telephone instrument used in conjunction with the water level

indicator may be used without any alterations or changes for ordinary talking purposes, by merely lifting the receiver from the hook and swinging the small loud speaker out of position. At the conclusion of the conversation, the loud speaker will automatically swing back to position in front of the transmitter.

A delayed action of the starting relays is employed so that the equipment will only transmit upon a sustained ringing indication, as normally transmitted by the automatic telephone ringer. This eliminates all possibility of the mechanism being affected by lightning or other interference on the telephone wires.

These instruments have been used by the United States Engineer Corps in Washington, D. C., for two years, in connection with the development of their new Filtration Plant at Dalecarlia, D. C., under supervision of Major Brehon Somervell, U. S. District Engineer, assisted by Edward D. Hardy, Principal Engineer, and P. O. Macqueen, Civil Engineer. They have given twenty-four hours unfailing service every day during this period.

The "telephone water level indicator" was designed and developed by Dewey M. Radcliffe, Associate Engineer, U. S. Corps of Engineers, writer of this article. The equipment was manufactured by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

FURNISHING WATER TO OUT-OF-TOWN CONSUMERS[1]

By Albert Heard[2]

The City of Hagerstown, Maryland, is probably in a different position regarding furnishing water to out-of-town consumers than most communities, owing to the fact that our water mains leading to the city distribution system from both sources of supply, the mountain reservoir on the east and the Potomac River pumping plant on the south, run along state highways, thereby making no expense to the city for connections for consumers. They pay for service pipes. We also have a water supply greater than the demands for a city three times as large as our present one.

We now have a capacity from the two sources of supply of 13 m.g.d., while our entire consumption, including outside consumers, is a little less than 4.5 m.g.d. Our rates to all out-of-town consumers are twenty percent higher than city rates, and on all pipe lines on streets requiring pipe extensions, a signed agreement is required from all property owners guaranteeing a return of 10 percent on the investment for pipe lines installed. The method used by the private company before city ownership was to me a more satisfactory arrangement than the present one, as under private ownership the property owners requesting water service were required to pay in cash the entire cost of extensions immediately upon completion of work. The money so paid to be refunded only after the revenues from the sale of water through these extensions equalled 10 percent per year on the entire cost for three consecutive years.

This method was a better investment for the company, as it created an incentive to hurry the building of houses to insure the return of the money advanced and the company was not compelled to lose the interest on this money for at least three years. However, we now solicit consumers outside the city in order to increase our consumption, which not only increases our revenue, but cuts the cost of pumping per million gallons, since by running pumps to capacity the

[1] Presented before the Four States Section meeting, April 1, 1931.

[2] Superintendent and Secretary, Board of Water Commissioners, Hagerstown, Md.

cost is materially reduced. Our pumping units are of 5 million gallons capacity each and by pumping this amount daily the cost is reduced at least 10 dollars per million gallons. At present, when using part mountain water, we furnish only about 2.5 million gallons through pumping. The balance is from our mountain supply, and for this reason we hope, through out-of-town consumers, with this slight increase in rates, to accomplish good results.

This city is supplying two small towns, Williamsport and Funkstown, Maryland, with a combined population of approximately 1600. These towns are furnished water through a master meter at a fixed rate per 1000 gallons and a minimum yearly rate to take care of fire protection, until consumption equals this minimum rate. Then a new contract is to be made, extending over a period of five years. During the past year, when a great many water companies were curtailing their consumption owing to dry conditions, this city was soliciting more consumers in order to get the revenues and reduce pumping expenses.

The city was compelled to increase its water supply in 1928 to take care of increasing demands and, in selecting the source, looked forward for fifty years in the future. Therefore, the present condition arose.

WATER SERVICE TO CONSUMERS IN AREAS OUTSIDE OF MUNICIPALITIES[1]

By Robert B. Morse[2]

Water supply problems may be solved more satisfactorily if approached from the standpoint of regional utility, except in the case of small isolated communities having practically no development beyond municipal boundaries. Wherever concentration of suburban population exists outside of a city's political limits, or wherever two or more independent municipalities are situated in reasonably close proximity to each other, some close form of administrative unity relating to water supply will facilitate service and effect economy. No phase of the problem benefits more strikingly from the eradication of municipal boundaries than that of extension of service.

Four primary methods exist for extending water service beyond city boundaries: Formation of water districts; enfranchisement of a water company for serving both the city and outlying areas; sale of water, at the city limits, to another municipality or to a water company which undertakes its distribution in the extra-jurisdictional territory; direct service from city-owned mains beyond the city boundary.

Under water-district or private ownership, if the district or enfranchised boundaries have been wisely chosen so as to include all outlying sections either closely settled at the time or promising early growth, the problem of the so-called "out-of-town consumer" is usually of little consequence. The advantages of living within a water district, for instance, become so evident to those just outside its boundaries that they demand admission for their neighborhood, sometimes even before water pipe extensions therein are justifiable from a financial standpoint. A potential out-of-town consumer thus often becomes one of the ordinary variety as soon as he and his neighbors decide that they want water service. About 7.5 square miles of area, having approximately 2,000 residents, are at the present moment being added to the Washington Suburban Sanitary District, with which the writer is connected, strict neutrality on the question

[1] Presented before the Four States Section meeting, April 1, 1931.
[2] Chief Engineer, Washington Suburban Sanitary District, Hyattsville, Md.

having been exercised by the Sanitary District officials. Representatives of those seeking admission stated to the Legislature that they were not "asking," but "begging," to be admitted. This is not the first time that territory has been added to that district at the instance of the affected locality.

No such favorable situation confronts the ordinary municipality when conditions make desirable the extension of its water system beyond the corporate limits. Annexation is usually delayed until long after water service becomes a necessity, since many other matters are involved. If the outlying territory is incorporated, it may, and generally does, construct and operate its own piping system and may contract with the central city for a supply of water. If, on the contrary, no municipal government exists in the section desiring water, and there is no water company, moreover, to undertake its distribution, or no real estate company to install the necessary mains, or the county authorities will not provide a system, as is generally the case, the only method remaining is for the city to install and maintain the distribution pipes outside its boundaries, as well as to supply the water. Under such conditions the city ordinarily deals directly with the consumer, as is the case inside the city limits, but generally in a different way.

Neither a water district nor a city can tax the residents of areas beyond its corporate limits, nor can they levy front-foot assessments. They generally can make special agreements, however, for payments by individuals which will cover not only the expense of serving water, but also the cost of installing the necessary pipes. Sometimes rates for service comprise the total charge, but oftener at least a part of the construction cost of necessary extensions is paid as a separate item, perhaps to be refunded when the annual return on the investment in the extension reaches 10 percent, as Mr. Heard states the arrangement to be in Hagerstown.

Whatever method of payment is adopted for service rendered to out-of-town consumers, the return should at least equal the total cost, whether for the sale of water delivered to a distribution system under outside ownership or directly to buildings beyond a city's boundaries through pipes owned by the city. Under no circumstances ought a consumer of this type be allowed to escape with less expense than one in town receiving equal benefit. It is often intended that he should pay more. The justice of this arrangement is unquestionable; its advisability, however, may be open to question in individual cases. Local circumstances should decide the point.

Proper charges for the outside consumer can be determined upon, manifestly, only after a thorough analysis has been made of the total cost of equivalent service within the municipality. The total cost must include all items covering the individual's share of the cost of construction, operation, and maintenance of the water system as a whole, no matter through what channels he may pay it to the city, whether through taxes, assessments, and service rates. It is the total payment that counts.

The writer does not look with favor on the common plan of determining the cost of individual pipe lines, either inside or outside of a municipality, for the purpose of fixing payments for extension of service. Payment should be made upon the basis of benefit received, not upon the size of pipe made necessary in the general design of the system, nor upon underground conditions, for neither of which items is the consumer responsible. The method is illogical, inequitable, and cumbersome. Above all, does the refunding plan appear unsatisfactory. Return on investment, as allocated to a single pipe line in a distribution system, proves hard to determine with exactness. Refunds cause extra labor and are a source of controversy.

A much less laborious and more equitable plan for fixing the charges to be made to out-of-town consumers would consist, the writer believes, in determining the actual total cost of the service, including the average cost per foot for the distribution system as a whole, and then requiring the consumer to pay, in one sum or a series of time payments, an amount equal to the capitalized charges made to similar city properties, through taxes or assessments, for construction costs (or such proportion of them as is thereby borne), and to pay in addition the regular rates obtaining for service within the city. Any extra burden which the municipality wishes to impose upon non-residents could be added in the form of a percentage to either the initial charge or the water rate, or both.

Emphasis should be laid on the equity of requiring an out-of-town consumer living along an existing city pipe line outside the corporate limits, or one buying water at the boundary, to pay a fair share of the capital cost of the system as well as the expense of delivering the actual water used. This point is often overlooked altogether, since giving the service requires little or no additional construction, or else the charge made over and above the city water rate may be regarded as a penalty for non-residency and is likely to be insufficient, as a matter of fact, for capital coverage.

PHOTO-ELECTRIC CONTROL OF CHLORINE FEED[1]

By John H. Harrington[2]

For some years the staff of the City of Montreal filtration plant have been working on the problem of controlling chemical feed of chlorine and alum in the process of purification and sterilization. The apparatus perfected experimentally and in successful operation for two years was demonstrated at the filtration plant laboratory during the Water Works convention in September, 1928.

In the Montreal assembly two color cells and two photo-electric cells are optically opposed on either side of a common point source of light in such a way that the beams after passing through the color cells are intercepted by the light sensitive cells. A small, but representative, sample of the water or other liquid under process, for example, water containing residual chlorine after addition of this chemical in the sterilization process is brought to the apparatus and equally divided streams must be available at either color cell.

These samples must exhibit the essential characteristic which is to be controlled and recorded in and for the main body of liquid under process. In chlorination work the sample must, with a suitable reagent, develop the residual chlorine test associated with a definite absorption period. In our work this is about four minutes.

Any one of the several recorder controllers used in annealing or other furnace work is practically a standard instrument for our assembly. By suitable mechanical means incorporated in or accessory to these instruments the color cells can be filled from the adjacent sample stream with or without automatic addition of reagent and can be again emptied in given cycles. The same mechanism will operate the electrical contact cycle.

In the chlorination process reagent is added on one side only, in the color development cell. It is evident that the intensity of developed color will vary with the residual chlorine content and more or less light will be intercepted by the photo-electric cell which will

[1] Presented before the St. Louis Convention, June 7, 1931.

[2] Chemist, Experimental Laboratory, Filtration Works, Montreal, Can.

function in the now well understood manner. By means of any standard recording and controlling pyrometer as mentioned above, a record of facts can be made and mechanical work done.

The optically opposed color cell exhibits a definite color standard. For chlorination this is conveniently composed of thin glass plates by combination of which different residual chlorine standards can be made.

Since the two color cells are optically opposed with reference to the light source, when they are filled with samples from the adjacent constantly flowing streams of water containing residual chlorine, the assembly functions as follows:

Diametrically opposed beams pass through the color cells and are intercepted by the photo-electric cells. These latter are in the arms of a Wheatstone bridge, the color development cell representing the variable resistance. If the assembly is balanced, say for a residual chlorine content of 0.20 p.p.m. then a color developed below or above the standard 0.20 will energize the chlorine feed valve motor to open or close this valve by suitable increments.

The cycle given below can be changed at will.

When the color developed equals the standard color no current flows in the galvanometer circuit and no change in feed occurs.

We have found this assembly sensitive to 0.02 p.p.m. In fact, it is too sensitive for our conditions and we have to provide a neutral zone on either side of galvanometer zero so that the chlorine valve will not operate for differences less than 0.04 p.p.m.

The arrangement automatically compensates for: (1) Variable lamp voltage; (2) turbidity, chlorination without filtration; (3) natural color, filtration without coagulation.

A straight line through center zero on the recording galvanometer shows that the residual has been maintained equal to the standard desired.

A second record can be made if desired showing what this residual was. For instance, we have a seasonal variation in safe residual chlorine content. When the Ottawa river is in flood we maintain approximately 0.30 p.p.m. after four minutes, but when the water is principally of St. Lawrence origin this can be decreased to 0.10 p.p.m.

Our experiments have been confined to the control of chlorine feed and alum feed, but the applicability of this class of apparatus will be very wide in industries that apply colorimetric methods.

INTERVAL SCHEDULE FOR PHOTO-ELECTRIC CONTROL OF CHLORINATION OF DOMESTIC WATER SUPPLY

1. *Dip reagent* by rotating dipping tube left to about 120° left of top vertical, into constant level reagent reservoir.

2. *Collect sample* by rotating dipping tube right to about 10° right of top vertical and hold under stream for about ten seconds then rotating left to at least vertical. This automatically mixes reagent and sample and discharges them to the color development cell.

3. *Five minutes pause.*

4. *Close test contacts* operating Wheatstone Bridge circuit.

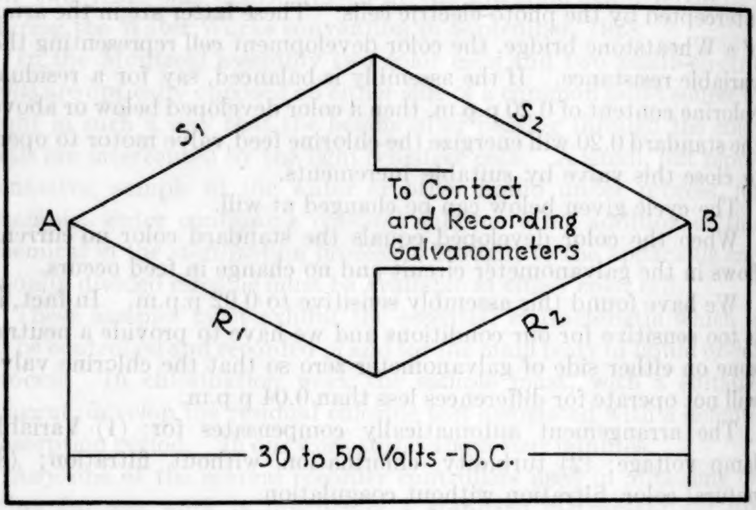

FIG. 1

5. *Thirty seconds pause.*

6. *Close recording contacts* which may also operate the chlorine valve motor.

7. *Ten seconds pause.*

8. *Open both contacts.*

9. *Empty color development cell* by raising valve in bottom of cell about ¼-inch and closing again before collecting the next sample. Repeat at any time interval desired.

The electrical circuits are shown in figure 1. S_1 and S_2 are the two

selenium cells, S_2 representing the one in relation to the standard color.

We have not found it necessary to have S_1 and S_2 of equal electrical characteristics. We have been adjusting any difference by means of the variable resistance at r, so that no current shall flow through the

TABLE 1

Photo-electric relation of residual chlorine to developed color and galvanometer current

RESIDUAL CHLORINE	DEVELOPED COLOR	UNBALANCED CURRENT IN GALVANOMETER CIRCUITS (MICRO AMPERES, APPROXIMATE)	MOTOR ENERGIZED TO CHANGE CHLORINE FLOW
p.p.m.			
0.1	Very faint blue	−0.96	Increase
0.2	Blue	−0.48	Increase
0.3	Distinct blue	+0.00	No change
0.4	Strong blue	+0.48	Decrease
0.5	Very strong blue	+0.96	Decrease

contact galvanometer when the standard color is developed in the reagent cell in relation with S_1. Under these conditions variable residual chlorine contents in the treated water cause variable unbalanced currents through the recording and contact galvanometers as shown in table 1, when the fall of potential (D.C.) from A to B is approximately 50 volts.

DISCUSSION

THE HYDRAULICS OF WELLS[1]

Authors for many decades have been writing on the hydraulics of wells, especially the laws of flow, the interference of one well upon another in a group of wells and the economic spacing of wells.

It would appear that all such scientific investigations, studies, writings, etc., have been based on the same fundamental hypothesis, including those of Slichter and Turneaure. German and French scientists forty years ago advanced the same hypothesis. It may be stated briefly as follows:

The flow of water from any porous media such as sandstones, sand and gravel formation, into a well or opening made into such porous media takes place in vertical planes and in radial lines centering in said wells and that lines of equal pressure about the well are circles with the center at well.

This theory is germane to the formula:

$$Q = \frac{KAh}{\text{Log}_e \frac{(R)}{1 + r}}$$

which is the basis of all of the formulas derived by the writer mentioned in the paper. The writer of the paper has evidently accepted this theory as true and has proceeded accordingly.

On this basis he has proceeded to develop a most interesting and instructive addition to our knowledge of the hydraulics of wells. Especially interesting is his analysis of the cost of a well system in reference to the spacing of the wells.

For something over 30 years I have been greatly interested in this subject because my work was largely along this line and at one time I spent considerable time in the libraries at Madison compiling data and derivations made by various writers. Although their formulas differed some in form and nomenclature they could all be reduced to the above given formula. I have never found this formula based on

[1] This JOURNAL, June, 1930, page 727.

this theory very practical, for it involved the constants or factors R and K which are extremely difficult to determine and cannot be measured directly for each problem. The writer of the paper has done more with them than any one with whom I have yet come in contact.

I have sought some formula which would be more workable and one which did not involve unknown factors not capable of ready derivation. For the purpose of bringing out discussion and to illustrate another theory I am going to say that I have for some time doubted the theory of radial flow into a well.

At Waupaca where the water supply is obtained from sand and gravel formations I put down a test well consisting of a 4-inch well point and a series of observation wells extended out from the test well in a straight line. The test well was pumped at a uniform rate until the lowering at all of the observation wells ceased to increase or in other words, until stable conditions had been obtained. The results of this test were plotted on logarithmic paper, values of lowering being plotted as ordinates against distance from test well as abscissae for each rate of pumping.

A straight line through the majority of these points gave the logarithmic equation; $\log L = A - B \operatorname{Log} X$ in which A is a function of Q as $\operatorname{Log} Q - M = A$. Placing the fundamental equation in the exponential form we have $L = \frac{A}{X^B}$.

According to Mansfield Merriman this is the equation of a vortex whirl. This relationship would indicate that water flowed into a well in much the same manner as water flows out a round hole in the bottom of a tank or basin, which follows the law of the vortex whirl. If this be so, a few remarks bearing on this subject might not be out of place.

Formations of either sand and gravel or of porous rock are seldom of uniform thickness over a considerable area nor are they of uniform texture. If the ground water has a direction of flow through the formation before pumping starts, it is doubtful if it becomes strictly radial after pumping has established a cone of depression about the well. Water in a reasonably smooth pipe never flows in straight lines or in the same direction for more than a few seconds at a time. It is constantly whirling and twisting. Waters of a stream even with relatively smooth bed always flows in more or less irregular lines.

At Waupaca where the above mentioned tests were made, I pumped

the well at the rate of 175 and 267 g.p.m. By substitution of these values in the log formulas above referred to the following equation was obtained: Log L = 0.93 Log Q − 1.023 − 0.6 Log X. "L" is the lowering of the water in feet at distance "X" from the center of the well.

By the use of this formula the drawdown L of any well whose radius X and the capacity in g.p.m. were assumed, could be computed.

It was predicted by this formula that a well 30 feet in diameter would supply about 1068 g.p.m. with a drawdown of 10 feet 2 inches. After the well was completed on actual test it supplied 904 g.p.m. with a lowering of 8.9 feet. Later an assistant engineer without my knowledge made a test by pumping the well at a rate of 732 g.p.m. He found a lowering of 7 feet 2 inches checking the formula within ⅜-inch in the lowering.

Just recently, after the well in Waupaca had been in operation for 8 years, I pumped at the rate of 720 g.p.m.; the lowering was 6 feet 2⅝ inches. By formula it would be 6 feet 10⅝ inches.

Since the Waupaca tests I have made similar tests at Port Edwards, Black River Falls, Nekoosa, Delavan and Antigo. Time does not permit me to give the full data of these tests or comparisons with the formula. The coefficients of Q and X were slightly different in each case, due to the physical characteristics of the formation. However, in each case the formulas derived from tests of small wells agreed closely with the capacity of the final well and were sufficient as a guide to produce a satisfactory well.

In some cases as at Antigo and Nekoosa it was necessary to make the test in proximity of an existing supply. The pumping of the existing supply interfered materially with the test so that it was difficult to work out a relationship between L and X that was consistent with all of the data.

Care should be taken also to pump long enough to get the water drawn down to stable conditions before taking the final readings. I applied this theory to the data submitted for the Rockford well mentioned by Prof. Mead. The formula agrees fairly well with the data near the shaft, but at 17,000 feet away the formula would indicate a greater drawdown than was observed. Possibly longer continuous pumping would have produced greater lowering as indicated by the formula. These drawdown curves have been used to determine the interference of one well upon another.

I have applied the hypothesis that, if one well of a gang of wells

were pumped at a given constant rate, its interference on any well within its circle of influence was measured by the lowering of the water in that well. If we were to assume that each one of a gang of three wells was pumped at the rate of 267 g.p.m. each, the total lowering at each well would be the lowering due to pumping that well plus the summation of the lowerings of each well upon each of the others. If the wells were equally spaced in a straight line and the drawdown curve derived by pumping one well were determined, the total drawdown can be readily computed by direct addition. Or if we wish to derive the total interference by formula and we let

L = lowering of pumped well in feet
Q = g.p.m. pumped from one well
M = constant in formula
a = exponent of Q
B = exponent of X
S = spacing of wells in feet
R = radius of well
N = Number of wells
I = Interference of all wells on one well

It can be readily shown that

$$I = \Sigma \frac{2\,Q^a}{M\,S^B} + \frac{2\,Q^a}{M\,(2\,S)^B} + \frac{2\,Q^a}{M\,(3\,S)^B} + \frac{2\,Q^a}{M\,\frac{(N-1\,S)^B}{2}}$$

$$\text{Ratio of I to L is} - \frac{2\,R^B}{S^B + (2\,S)^B + (3\,S)^B \text{ to } \frac{(N-1\,S)^B}{2}}$$

Stated in another way, for any given set of conditions and rate of pumping, the interference is a function of spacing of and radius of wells. Applying this principle of interference to a gang of 10 tubular wells, one of which was being pumped at the rate of 266 g.p.m., it was found by the formula that the pumping of 700 g.p.m. would produce a lowering of $7\frac{1}{2}$ feet. On actual test the pumping of 700 g.p.m. produced a vacuum at the pump of 9 feet which included the friction in the suction pipe between wells. Allowing that this friction loss was 1 to $1\frac{1}{2}$ feet it makes a pretty close check on the formula.

At Black River Falls a test was made on a small dug well and observations were made on a number of driven wells located along a

straight line from center of test well. The formula for the flow into this well was Log L = 0.569 Log Q − 0.217 − 0.6 Log X.

It was desired to obtain 300 g.p.m. from a new development. The formation was fine sand and the test showed a small flow. A design was therefore made for a hollow dam crossing the small creek

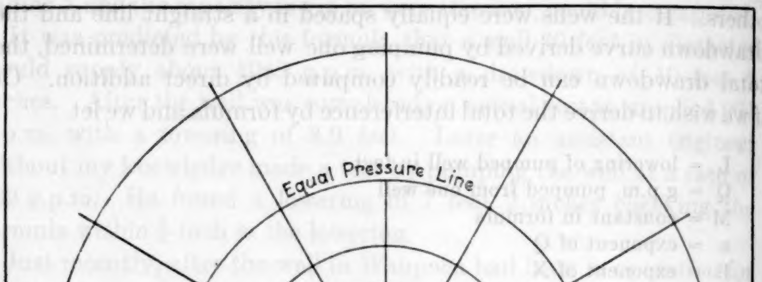

Fig. 1

valley adjacent to where the test was made. The hollow dam was 128 feet long and had porous concrete screens on each side packed with selected sand and gravel of assorted sizes. The above mentioned theory of interference was applied to the design and it was found that the estimated capacity of 300 g.p.m. could be obtained by a lowering of 10 feet.

After the structure was complete a test was made by a pump that was rated at 300 g.p.m. The hours of pumping were never quite long enough to bring the water level down to quite that derived by the formula, but it was sufficient to show that the theory derived herein was a safe one to follow for capacities in this range.

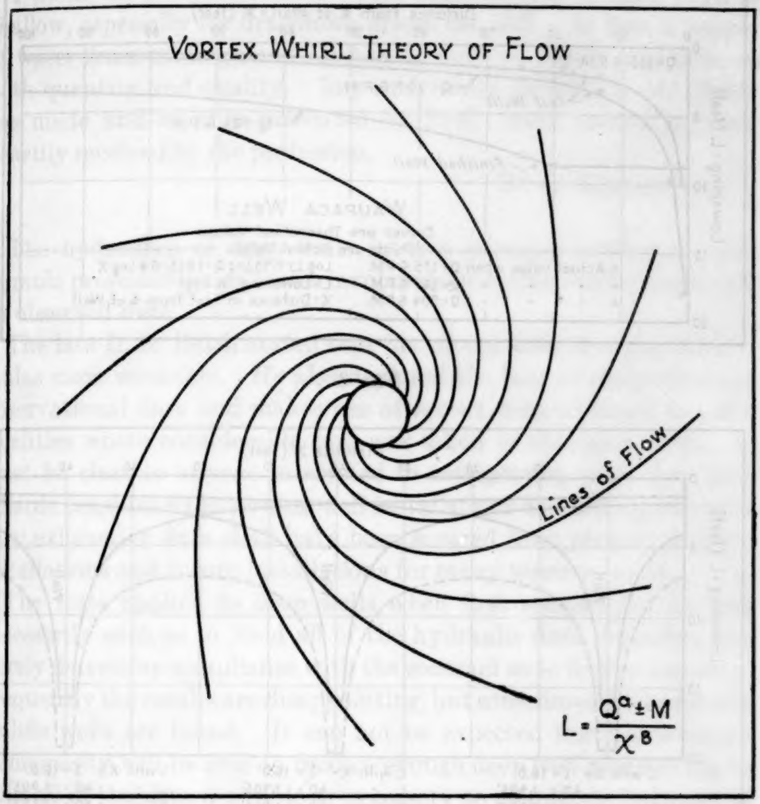

FIG. 2

A plan of a well with radial lines of flow and equal pressure lines about the well, according to the theory used by Slichter, and others is shown in figure 1.

In Figure 2 a plan of a well, with curved lines of flow about the well being pumped is shown, according to the hypothesis assumed by the speaker.

Drawdown curve of the Waupaca test wells when being pumped

at the rates of 175 and 267 g.p.m. and for a completed well, with complete formula for flow, is shown in figure 3.

Interference curve for a gang of wells, with curve of drawdown for one well and the table for interference, are presented in figure 4.

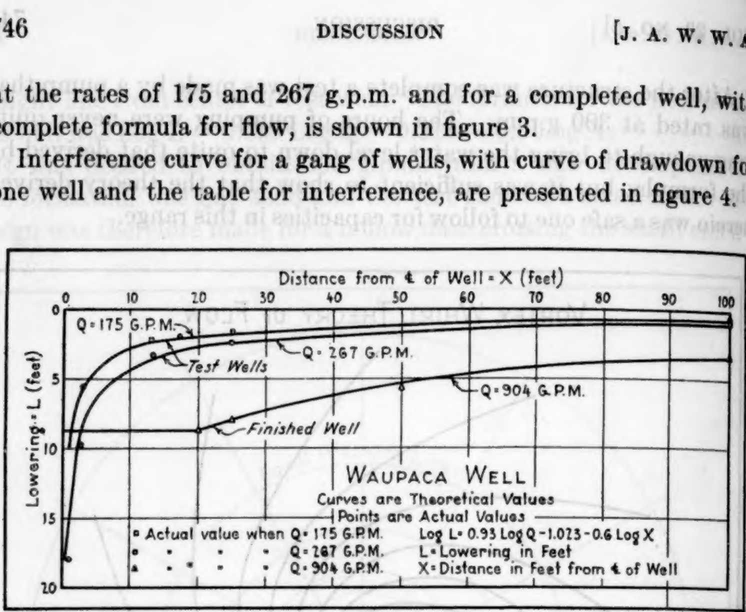

Fig. 3

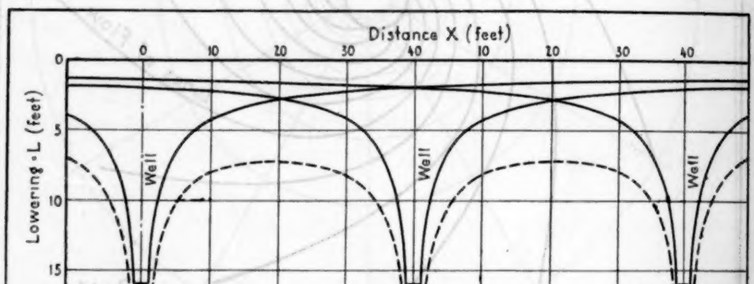

Fig. 4

I realize that my method requires a pumping test to secure the constants used in the formula for flow or value of lowering for interference curve, but, if a number of tests have been made on formation

of same general characteristics as, for instance a sand and gravel formation having a certain fineness modulus, it would be possible to approximate closely the flow into any other well system without a test, after samples of the formation had been tested for fineness by a set of sieves.

I think the general formula would apply as well to deep wells as shallow, especially for drawdown about the well. At best a supply of water from underground sources is more or less of a gamble on both quantity and quality. Any such study as the late Mr. Balch has made and so ably presented by Prof. Mead should be most heartily received by the profession.

W. G. KIRCHOFFER.[2]

The hydraulics of deep wells involve peculiar problems. Any formula presumably applicable involves factors that can be based only on observed data.

The late L. R. Balch stated that his efforts were to make the formulas more workable. He also deplored the lack of comprehensive observational data and makes use of recent data obtained in a few localities where considerable care was taken in obtaining them. It must be clear to anyone interested in interpreting such data that reliable conclusions governing well installations will not appear until very exhaustive data shall have been secured from present working installations and future installations for many years to come.

The tests applied to deep wells when first constructed are not necessarily such as to yield all of the hydraulic data desirable, but merely determine compliance with the contract as to flow or capacity. Frequently the results are disappointing, but sometimes unexpectedly prolific wells are found. It can not be expected that the average municipality will be able to finance enough deep well prospecting to yield all of the data desirable or necessary to enable the engineer to reach safe workable conclusions. Therefore, assumptions must be made, trial formulas developed, and the meager data utilized so far as possible.

A deep well is usually described by giving depth, diameter of casing at the ground level and at bottom of well, static height of water, lowering of water when pumped at a given rate and possibly the lowering when pumped to full capacity of the pump. More often

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the working capacity of the well is a matter of conjecture. Flowing wells are usually considered on the basis of hydraulic head, but the quantity of flow is influenced by the same variable factors giving the capacity of pumped deep wells. That all deep wells are not flowing (artesian) is purely accidental geologically.

The stored water withdrawn by the pumping of a deep well marks the deficit to be restored from the water bearing strata under conditions of permeability and release, factors vital to the permanency of the flow. The sandstone strata are the principal aquifers, other rocks furnishing water only as creviced or traversed by streams, or veins, perpetuated during the formation and placement of the rock strata.

In the final analysis the practical view of the problem of supply is that of drawdown and replacement. Drawdown implies responsive yield and replacement requires extensive area of influence, commonly described for convenience as circle of influence.

Again for some reason in practice the radius of influence has been assumed as 200 meters, or roughly, 600 feet. It is a very limited field when defined with so short a radius. More recent data indicate much larger radii, even to the extent of 50,000 feet, or approximately 10 miles.

Therefore, drawdown and radius of influence are the principal factors. All other factors involved simply lead to a mathematical refinement of the problem little understood or appreciated by those commonly engaged in the installation of deep wells.

Shall we accept the statement of Turneaure as quoted in the paper under discussion that "essential data of the amount of water actually flowing in the ground are all included in R, the radius of the circle of influence." Certainly the amount of water flowing in the ground is the vital consideration. The replenishing or replacement power depends on that condition. A circle of influence of less than 600 feet does not provide much output or recovery. The writer recalls one Iowa town where three 10-inch wells, 135 feet deep, were located in a river valley, in very porous limestone, spaced 155 feet apart, with static head 10 feet from the surface. Continuous 36-hour pumping tests were carried out, singly and in groups. One well yielded 110, the second 95, and the third 60 g.p.m., the draw-down being 48 feet, constant with wells pumped singly. Grouping gave about two feet more of drawdown, the interference cutting down the individual yield of the wells approximately 15 percent. The geology

of the strata as indicated by other wells near and remote and the static head in such wells warrant the assumption that the value of R in this case exceeded one mile while a computation gave in excess of 7000 feet for R. These have not yet been put into commission, therefore, the perpetuation of the supply is undetermined.

Another Iowa city takes its supply from four 12-inch gravel-packed tubular wells approximately 40 feet deep, static head 12 feet from the surface. These wells are located in a valley water field approximately one mile wide, extending indefinitely upstream. The sand and gravel strata are stream laid. The wells are located in a line at right angles to the down-stream flow as determined by test wells. Each of these, which are 146 feet apart, yields a constant flow of 1150 g.p.m. with 9 feet drawdown. Pumped all together the yield is 1150 g.p.m., with 3 feet drawdown. In this case the value of R is probably 3000 feet, but there is a great volume of water flowing to the wells. Also in this case it would seem needless to apply any formulas, but we expect to make observations of elevation and change of water table from time to time. The four wells could give four times the present demand, and twenty wells could be placed in this field without serious interference.

In another case, now under observation, four gravel-packed wells 35 feet deep, spaced 160 feet apart, are located in stream-laid sand and gravel. With a drawdown of 5 feet the output of all wells pumped together, when first installed was 800 g.p.m. Wells pumped singly yielded 300 g.p.m., showing an apparent interference of 33 percent. The field is limited, perhaps 1000 feet wide and 4000 feet long, mostly up-stream from the location of the wells, and the water table has lowered about 12 feet in seven months pumping, under drought conditions. Observation in test wells up stream gives a value of R as 3000 feet. Computation gives R as 2500 feet. This is not a fair illustration of the use of formulas since the field is not in correct dimensions to apply the rule for circle of influence. In this case we are putting in additional wells and will pump some of the wells with turbines when the water table recedes below the lift of the horizontal centrifugal pumps. A return of normal rainfall will restore the water table to original elevation.

In both of the two preceding cases of wells located in stream-laid sand and gravel the movement of water down stream is close to 5000 feet per year.

The writer sees no necessity of limiting the application of the use

of the formulas to deep wells proper. It even appears the formula might be more profitably applied to the problem of shallow wells.

Not every region will allow the use of shallow wells or deep wells, yet the earlier view was the deep well as the solution of the water problem. It is possible, however, to obtain the data which will verify or correct the formulas by means of widely placed test wells in a surface water field, without an immense outlay of funds.

The one item of greatest value in this study of the hydraulics of wells is interference of wells. Everywhere we may observe the mistakes made in the close spacing of wells, both deep and shallow. It is quite common to find several deep wells within the floor space of an ordinary pump house. If ever the total flow from two or more wells in the same pump house is more than any one of the wells it is probably because the wells are of too small a diameter to deliver the water available. Duplicate wells in the same location are simply necessary for reserve units in case of needed repair. In grouping of shallower wells in large water fields, where all out doors is available, until recently the common method was to group the wells close to each other, sometimes within 30 to 50 feet apart, and rarely as much as 100 feet apart.

In the foregoing instance where the very prolific output was obtained by the four gravel-packed 12-inch tubular wells the old wells were closely spaced. Four 6-inch and four 8-inch wells were located within a radius of 100 feet. A single 12-inch gravel packed well located in the center of things gave a greater yield than all of the lesser wells combined. This information was used in the location of the latter fields and in the spacing of the new wells. The results are all that could be desired.

It appears to the writer that the information given thus far on the interference of wells, in the paper under discussion, and in recent publications, is of untold value, and would form the basis of a program of relief from shortage of water supply in a large proportion of such water supplies.

The writer does not attach great significance to the economic spacing of wells as set forth by the writer of the paper under discussion. A water field might be sufficiently prolific to set the cost of connections against the reduction of yield by interference, but it would appear that in the great majority of cases the greater yield is necessary for the demand and would govern the spacing of the wells.

In concluding this brief discussion the writer desires to express his appreciation of the merits of the paper under discussion and also to recognize the value of the contribution to the literature relating to public water supplies.

LAFAYETTE HIGGINS.[3]

[3] Consulting Engineer, Des Moines, Ia.

SOCIETY AFFAIRS

THE INDIANA SECTION

All sessions of the twenty-fourth annual meeting of the Indiana Section were well attended on February 26 and 27, 1931. More than two hundred were registered.

At this meeting considerable attention was given to legislative matters affecting the water supply and general health of the state. Resolutions were passed: (1) Urging that the State Department of Health be not hampered in its work by a reduction in its appropriation; (2) urging the assembly to pass the "Stream Pollution" law; (3) approving the bill providing full time health officers in counties or districts.

J. H. Armington, Senior Meteorologist, Indianapolis Weather Bureau, gave a talk on drought conditions in the United States with special emphasis on Indiana. Southern Indiana suffered most severely and continuously throughout the year. In only one small area, precipitation was normal. Despite the very severe reduction in water supply in certain areas, no water borne disease epidemic occurred.

The drought conditions in Ohio were reported by F. H. Waring, Chief Engineer, Ohio Department of Health. In the northern part of Ohio, where surface supplies are used for the most part, various expedients were adopted to correct taste and odor troubles, which were unusually severe on account of low water. The ammonia-chlorine treatment is not effective, except in the case of phenol. At Delaware, Ohio, tastes were corrected by the use of approximately 3 pounds of permanganate per million gallons, followed by lime treatment. At Warren, 7 pounds of chlorine per million gallons gave no residual on account of the high organic content. At one plant 50 pounds per million gallons of activated carbon, costing four dollars, were applied by dry feeding in the mixing chamber ahead of the coagulant, and was found to be effective in removing the river taste. The low water increased the hardness, that at Cincinnati being the highest since the plant was started in 1907. Mr. Waring stated that exceptional ability on the part of the operators was made apparent

during this emergency, and likewise the plants operated by inferior men suffered most. While during the drought period, domestic use of water increased, the industrial depression reduced the quantity of water required for manufacturing and unusual peak loads were not noted.

Mr. George H. Fenkell, President of the American Water Works Association, attended the session and addressed the luncheon meeting. He emphasized particularly the necessity for eliminating the spoils system in the operation of water plants and the necessity for maintaining a high quality effluent at all times.

In connection with current legislation, Dr. W. F. King, deplored the lack of full time health officers in the drought stricken area of Indiana. While no serious epidemics have developed in this region, anxiety is felt for the immediate future since in this area considerable undernourishment exists.

The water supply at Ft. Wayne has in the past been taken from deep wells. This water has been very hard and contained some iron. Mr. R. L. McNamee described the studies made to determine the best source to use for a new supply and, on account of low hardness and organic load, the St. Joseph river was chosen. A dam will be constructed to provide storage and the water will be carried to the city a distance of about ten miles for treatment. Mr. McNamee called attention to the fact that a profit in soap alone will amount to about $6.00 per capita, after deducting the cost of operation and fixed charges for the softening and of the new treatment.

Mayor Wm. H. Hosey stated that the present city water works of Ft. Wayne is fifty years old this year. The total valuation of taxable property is $230,000,000. For the new plant, which is to cost more than $2,500,000, the city will issue bonds to be retired within twenty-five years from water rates. The rates now in effect, as applying to medium sized domestic service, average about $6.00 per year. The city is fully metered and to finance the new plant the minimum charge will be doubled and the new rate will be $12.00 per year for quantities under 500 cu. ft. per month.

In the past water has been sold especially on the basis of its safety. Mr. H. E. Jordan, Filtration Engineer of the Indianapolis Water Company, called attention to the fact that it is just as important to produce a water satisfactorily from a standpoint of taste and odor and stable, so far as deposition is concerned. While the ammonia chlorine treatment was known in 1907 and actually used in Ottawa

in 1915, mechanical difficulties in its use delayed its wide spread application until recently. At the Indianapolis plant very considerable advantage has been found in its use, particularly in prechlorination. Anhydrous ammonia, as well as ammonia sulphate, have been used and no difference in the effect is found when the same pounds of ammonia (NH_3) are applied. In prechlorination 1 pound of ammonia to 2 pounds of chlorine is found advantageous and for a total chlorination, both before and after filtration, 1 pound of ammonia to 3 pounds of chlorine are recommended. The treatment is very effective against phenol taste and has a tendency to correct mustiness.

Mr. H. W. Williams of St. Paul, Minnesota, discussed well capacities from a theoretical and practical standpoint. In drilling limestone wells the drilling should be continued through the layer of stone, while in ground wells the drilling should be continued only so long as interstices are encountered. Recognized methods of finishing gravel wells were given in some detail, as well as the interfering effect of adjacent wells.

Mr. L. S. Finch, Chief Engineer, Indiana State Board of Health, recounted some difficulties encountered during the drought in Indiana and the detail of relief measures inaugurated at some of the worst points.

Mr. F. P. Stradling described the iron removal plant at Kokomo where the water comes from deep wells. The cost of operation of the purification work is estimated at $16.00 per million gallons.

Discussion on avoidable water works losses was led by Frank C. Jordan, Secretary, Indianapolis Water Company. The subject was covered from production of water through the power plant and distribution system.

Mr. H. S. Morse presented a tentative rating scale for water departments, which he asked the members to examine carefully and present criticism to him for the use of his committee. In this way he believes the operation of the utility, as well as its service to the community may be improved.

The unemployment situation was discussed during an entire session. Dr. Jas. H. Greene of the Studebaker Corporation, South Bend, expressed the opinion that the general unemployment situation must be met by the development of new industries. He stated that he felt the present depression was due in no measure to the change from hand to machine methods, since he believes that there is

just as much demand for skilled workmen now as there was thirty years ago.

The situation in Indianapolis and the measures taken to relieve unemployment were presented by Wm. H. Book, Director of Civic Affairs, Indianapolis Chamber of Commerce. Mr. Book's committee has obtained considerable money by benefit performances and from the regular relief agencies, as well as from the township trustees, and is expending this money on public work for which no specific appropriation has been made. In this way, the men, whose family must be given charity, are kept occupied on work of advantage to the entire community.

At the end of the session the following officers were elected: President, L. S. Finch; Vice-President, F. P. Stradling; Section Director, H. E. Jordan; Secretary-Treasurer, C. K. Calvert and Assistant Secretary-Treasurer, Wm. Luscombe.

C. K. Calvert,
Secretary-Treasurer.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Report of Committee A-5 on Corrosion of Iron and Steel. J. H. GIBBONEY, et al. Proc. Am. Soc. Testing Materials, 1929 (preprint) No. 12. From Chem. Abst., 23: 4917, October 20, 1929. Data on continuations of atmospheric and submerged corrosion tests of Committee A-5 are presented, without conclusions as to the relative corrodibilities of the various metals tested.—*R. E. Thompson.*

A Critical Study of the A. S. T. M. Corrosion Data on Uncoated Commercial Iron and Steel Sheets. V. V. KENDALL and E. S. TAYLERSON. Proc. Am. Soc. Testing Materials, 1929 (preprint) No. 37, 16 pp. From Chem. Abst., 23: 4917, October 20, 1929. None of the elements added seemed to have any effect on submerged corrosion.—*R. E. Thompson.*

Galvanized Pipes. (Metal Coating.) M. GRELLERT. Apparatebau, 41: 128, 1929. From Chem. Abst., 23: 5145, November 10, 1929. Inside galvanizing cannot be used for pipes conducting water which contains carbon dioxide, because of the action on zinc. Copper piping is recommended. Inside galvanizing is not necessary where very hard water is to be conducted as the lime deposit inside the pipe will furnish sufficient protection against rust. Inside galvanizing gives very good protection where water is of medium or low hardness and prevents the yellowish, reddish, and dark coloring of the water. Outside galvanizing provides very good protection against rust formation on pipes carrying cold water where sweating of the pipes occurs.—*R. E. Thompson.*

Galvanized Pipes. (Metal Coating.) M. GRELLERT. Apparatebau, 41: 115, 1929. From Chem. Abst., 23: 5146, November 10, 1929. A discussion of the relative merits of zinc as a protective coating on metals.—*R. E. Thompson.*

Water Purification in the Low Countries. W. F. J. M. KRUL and F. A. LIEFRINCK. L'Eau, 22: 68–74, 1929. From Chem. Abst., 23: 5255, November

[1] Vacancies on the abstracting staff occur from time to time. Member desirous of cooperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

10, 1929. General discussion of water purification problems and installations in Holland and Belgium.—*R. E. Thompson.*

Spectroscopic Determination of Small Quantities of Strontium, Barium, and Cesium in Minerals, Rocks, Mineral Waters, etc. F. Zambonini and V. Cagiloti. Atti accad. Lincei (vi), 8, 268–73, 1928. From Chem. Abst., 23: 5128, November 10, 1929. A spectroscopic method is described by which small traces of elements (strontium, barium, and cesium) in minerals and waters may be determined with a degree of accuracy much higher than is usually obtained. Dealing separately with solutions of the alkaline earths, the effects of dilution and addition of comparatively large quantities of the other alkaline earth salts on the intensity of characteristic lines is shown, with considerable data.—*R. E. Thompson.*

The Effect of Cold-Working on Boiler Drums. Frederick G. Straub, H. S. Newlin, R. K. Hopkins and H. LeRoy Whitney. Power, 69: 998–1002, 1929. From Chem. Abst., 23: 5141, November 10, 1929. Caustic embrittlement due to high carbonate alkalinity occurs only where fabrication has set up internal strains. Various types of strains are illustrated with photomicrographs. Plates should be uniformly heated in a furnace to a temperature just above the upper critical range of the steel to eliminate strains.—*R. E. Thompson.*

Recent Developments in Boiler-Metal Embrittlement. H. F. Rech. Mech. Eng., 51: 589–93, 1929. From Chem. Abst., 23: 5141, November 10, 1929. A discussion of boiler-metal embrittlement in which it is brought out that it is important to keep the sulfate-carbonate ratio sufficiently high, if failure of the tubes is to be prevented.—*R. E. Thompson.*

Caustic Embrittlement *vs.* the True Cause of Boiler-Plate Failures. E. F. Baker. Eng. & Finance, 21: 80–4, 1929. From Chem. Abst., 23: 5257, November 10, 1929. When boiler water contains both caustic and oil, as is frequently the case, a very non-uniform circulation of the water is likely to take place. This causes a rising and falling of the water in the boiler with resultant impact. The strains set up by these rapid impacts cause failures which have been frequently incorrectly laid to caustic embrittlement.—*R. E. Thompson.*

Some Results of Boiler Water Conditioning. R. E. Hall. Iron Steel Eng., 6: 380–9, 1929; cf. C. A., 23: 4985. From Chem. Abst., 23: 5257, November 10, 1929. A summary and discussion of the Hall system of boiler water conditioning, with numerous examples of its practical application.—*R. E. Thompson.*

Distribution and Velocity of the Corrosion of Metals. Ulick R. Evans. J. Franklin Inst., 208: 1, 45–58, 1929. From Chem. Abst., 23: 5146, November 10, 1929. Oxygen is needed for corrosion, but the attack occurs at places relatively inaccessible to oxygen. The direct effect of oxygen is to maintain a

protective film and the indirect effect is to set up corrosion where the film is weak. The protective effect of various oxides depends upon the rate of oxidation of the metal, thickness of film, and its mechanical strength. Localized attack is due to differences in the state of repair of the protective film. This is affected by certain ions which have the power to penetrate the film at its weakest points. Where corrosion has spread out over a large anodic area the penetrating power of ions is unimportant. Film formers if not present in sufficient quantities tend to isolate the corrosion at points with the ultimate formation of deep pits. For success the metal must be chosen so that the primary reaction product is protective, as secondary products do not in general prevent attack. The velocity of corrosion is a function of both the oxygen supply and the nature of the metal.—*R. E. Thompson.*

The Corrosive Action of Water on Pipe Lines. H. Winkelmann. Apparatebau, **41**: 146, 1929. From Chem. Abst., **23**: 5258, November 10, 1929. Corrosion is increased considerably by the presence of air. The mechanism of rusting is explained as it occurs in industrial installations. The importance of removal of the air from water is stressed.—*R. E. Thompson.*

It Does Not Pay to Return Boiler Blow-Off to the Feed-Water Softener. J. D. Yoder. Power, **70**: 442–3, 1929. From Chem. Abst., **23**: 5258, November 10, 1929. The mixture of substances in blow-off is not useful for further softening.—*R. E. Thompson.*

The Treatment of the Waste Waters of a Sugar Factory with Chlorine. Ernst Nolte. Z. Ver. deut. Zuckerind., **79**: 463–9, 1929; cf. C. A., **23**: 4003. From Chem. Abst., **23**: 5259, November 10, 1929. The results of some chlorination tests on a large scale are given. Chlorination of waste waters does not destroy or eliminate organic matter; but hydrogen sulfide and sulfides which cause mal-odor are destroyed. Fresh waste waters when chlorinated do not ferment. Intermittent chlorination is more economical than continuous chlorination. Dead corners in the drain serve as breeding grounds for bacteria, and so may reimpregnate the water and defeat the aim of chlorination. Complete fermentation methods of purification were used successfully. Fermentation, liming and chlorination methods may prove useful in recovering waste waters where there is a shortage of water.—*R. E. Thompson.*

A Process for Rendering Harmless the Waste Waters from a Beet-Sugar Factory. H. Bach. Z. Ver. deut. Zuckerind., **79**: 241–50, 1929. From Chem. Abst., **23**: 4362, September 10, 1929. Waste waters of beet sugar factories introduced into streams may cause the death of fish by depleting the oxygen content of the water. The waters also contain substances toxic to fish, but in too great dilution to cause trouble. Only the waters from the diffusion battery and the presses are harmful. A remedy is aëration of the waste waters either before or after introduction into the stream.—*R. E. Thompson.*

Views on the Proposal of Dr. Bach Relative to the Rendering of the Waste Waters of Beet Sugar Factories Harmless. Paul Hirschfelder. Z. Ver.

deut. Zuckerind., **79**: 420–1, 1929; cf. C. A., **23**: 4362. From Chem. Abst., **23**: 5259, November 10, 1929. It is pointed out that fungi and algae formation is also responsible for the trouble caused by introducing the waste waters into streams. These fungi and algae may foul turbines. Streams in which the water is well aërated by flowing over obstacles are especially rich in algae and fungi. These streams may be perfectly clear, fouling and fermentation occurring only in dead corners. Fishermen claim that fungi drive away fish. In some streams, where flow is slow, oxygen may be deficient for fish life, but aëration causes the growth of algae and fungi. A remedy at one factory may fail completely at another; each case must be decided by experiment. Even injection water from condensers causes algae and fungi growths.—*R. E. Thompson.*

The New Water Laws in Mecklenburg. M. Grevenmeyer. Wasserkraft u. Wasserwirtschaft, 1929, 184–5: Wasser u. Abwasser, **26**: 101. From Chem. Abst., **23**: 5255, November 10, 1929. Regulations regarding the use and purity of water supplies include compulsory treatment of industrial wastes to avoid contamination.—*R. E. Thompson.*

Mineral Analyses of Municipal Water Supplies in Kansas. Selma Gottlieb. Univ. Kansas Bull., **29**: No. 17, 9 pp., 1928. From Chem. Abst., **23**: 5255, November 10, 1929. A tabulation showing water hardness determinations from 289 municipalities.—*R. E. Thompson.*

A New Electric Salinometer for Testing Drinking Water. R. Mauschke. Apparatebau, **41**: 145, 1929. From Chem. Abst., **23**: 5256, November 10, 1929. A description of Crockett's simple salinometer, the operation of which depends on the principle that the conductivity of a dilute salt solution is proportional to the concentration.—*R. E. Thompson.*

Field Practice in Chlorination of New and Old Water Mains. J. S. Strohmeyer. Hydraulic Eng., **50**: 8, 34–6, 1929. From Chem. Abst., **23**: 5257, November 10, 1929. Apparatus required for chlorination of water mains and its operation described. The cost is 1 cent per foot using hypochlorite of lime and 2 cents per foot using chlorine gas. Also in Surveyor, **76**: 147, 1929.—*R. E. Thompson.*

The Helsingfors Swimming Pool. R. Kreüger. Tek. Fören. Finland Förh., **49**: 149–51, 1929. From Chem. Abst., **23**: 5258, November 10, 1929. The purification system consists of an aërating tank, a filter for removing hair, and a pressure filter; 0.2 p.p.m. chlorine being applied subsequently.—*R. E. Thompson.*

The Chemist and the Disposal of Waste Products. V. G. Anderson. Proc. Soc. Chem. Ind. Victoria, **27**: Nos. 1–4, 1381–6, 1927. From Chem. Abst., **23**: 5259, November 10, 1929. A general discussion of the disposal of trade and municipal wastes, with particular reference to conditions in Victoria.—*R. E. Thompson.*

Studies on the Stability, Bleaching Action, and Products of Decomposition of Hypochlorite of Soda Solutions. V. I. Minaiev, P. Formin and G. Yakimov. Rev. Gén. Mat. Color., 33: 297–9; 337–9, 1929. From Chem. Abst., 23: 5279, November 10, 1929. Tabulated results are given showing properties of hypochlorite solutions prepared from various concentrations of sodium carbonate and chlorine. A 13° Bé. lye containing 93 percent of the theoretical percentage of chlorine is the most stable.—*R. E. Thompson.*

Softening industrial Water for Textile Purposes. S. R. Trotman. Dyer, Calico Printer, 62: 17–9, 147–9, 1929. From Chem. Abst., 23: 5321, November 10, 1929. The use of base exchange compounds for water softening, the reactions involved, and the advantages and disadvantages of this method are discussed.—*R. E. Thompson.*

Soap Losses in Hard Waters. R. Krings. Seifensieder-Ztg., 56: 285–7, 1929. From Chem. Abst., 23: 5342, November 10, 1929. Fifty liters of Berlin tap water of 16° hardness (German) precipitates 88 grams pure soap, equivalent to the total fatty acid content of 1 pound of soap powder containing 16 percent soap. If the sodium carbonate and sodium silicate of this powder are separately dissolved in water and the 16 percent soap is added afterwards, only one-half the soap will be precipitated and if this procedure is repeated with the addition of the calculated amount of sodium hydroxide before the soap is added, then the total amount of soap will go into solution without being precipated.—*R. E. Thompson.*

The Method of Centrifugal Casting. H. Simon. Z. Metalkunde, 21: 302–4, 1929. From Chem. Abst., 23: 5455, November 20, 1929. General discussion, including history, centrifugal casting of iron, simple and difficult castings, desirable properties, etc.—*R. E. Thompson.*

Protective Coatings. J. K. Crowell and E. F. Schuldt. Proc. Am. Gas Assoc., 1928: 1458–61. From Chem. Abst., 23: 5335, November 10, 1929. Procedures for testing protective coatings have been reviewed and the following procedure is suggested for coatings for underground piping. For determining water-proofing ability, porosity, and electrolysis, the inside of a metal dish, 12 by 12 by 3 inches, is painted and dried according to specifications and then filled with distilled water containing 20 grams sodium chloride per liter. Ieto this is vertically suspended, within 1 inch of bottom, a metal plate, 2 by 4 inches, which is connected to the dish through a milliammeter and the positive pole of 2 dry cells. The milliamperes are recorded against time (days) as a record of the durability of the film. For the Harper test, strips of 28-gage black iron, 3 by 6 inches, are punched near one end for hanging, cleaned, dried, and weighed. These are painted, weighed, and allowed to dry to constant weight; drying time should be noted. The resistance of the strip between 2 wet weighed discs (Harper Tester) is determined by means of a Whitney ohmmeter; then one strip is placed in each of the following solutions: tap water, distilled water, 0.01 percent sodium chloride, 0.01 percent sodium hydroxide, 0.01 percent sulfuric acid. At the end of one week the resistance is again

measured and the procedure repeated until characteristic failures are noted. Bibliography appended.—*R. E. Thompson.*

Stabilized Starch Indicator. M. Starr Nichols. Ind. Eng. Chem., Anal. Ed., 1: 215–6, 1929. From Chem. Abst., 23: 5430, November 20, 1929. To 50 grams of potato starch add 250 cc. of cold water and triturate to a thin paste. Pour it gradually with stirring into 20 liters of boiling water. Cool and add 25 grams of salicylic acid. Use 2 cc. in a titrating volume of 200 cc.—*R. E. Thompson.*

The Phenomenon of Oligodynamic Action. Salt Inhibition. N. Leitner. Zentr. Bakt. Parasitenk., I Abt., 112: 368–75, 1929. From Chem. Abst., 23: 5510, November 20, 1929. The oligodynamic action of copper "activated" water was inhibited by sodium chloride concentrations between $M/8$ and $M/32$, but not by higher or lower concentrations. Chlorides of potassium, calcium and aluminum gave similar curves.—*R. E. Thompson.*

Determination of Aluminum in Plants. I. Study of the Use of Aurintricarboxylic Acid for the Colorimetric Determination of Aluminum. O. B. Winter, W. E. Thrun and O. D. Bird. J. Am. Chem. Soc., 51: 2721–31, 1929. From Chem. Abst., 23: 5431, November 20, 1929. Some difficulties were encountered in carrying out the colorimetric determination with aluminon by previously described methods. The conditions were studied carefully and the method was modified so that 0.005–0.070 milligram of aluminum can be compared with a standard and the amount of aluminum read directly from a curve. Maximum color was obtained in the presence of 10 percent ammonium acetate when the solution was kept at 80° for 10 minutes and at pH 4 (approximately). In the presence of 25 milli-equivalents of both ammonium acetate and ammonium chloride, the dye changed color at pH 7. A neutral or alkaline solution of 2 cc. of 0.1 per cent dye in volume of 50 cc. was nearly colorless. The lake color was sufficiently permanent for color comparison until the pH was raised to 7.4. Ammonium acetate and ammonium chloride were found to be advantageous for controlling the acidity and ammonium carbonate was found more advantageous for decolorizing the excess dye than either ammonium hydroxide or ammonium hydroxide and ammonium carbonate.—*R. E. Thompson.*

A New Enrichment Method for Typhoid and Paratyphoid Bacilli in Water and Feces. Friedrich Hoder. Zentr. Bakt. Parasitenk., I Abt., 113: 353–7, 1929; cf. C.A., 22: 4144. From Chem. Abst., 23: 5484, November 20, 1929. A stock solution of malachite green 1:250 and of brilliant green 1:200 was used. Mix 38.5 cc. sterile water, 5 cc. of sterile bile, and 5 cc. of bouillon and add the material to be examined. Add 0.8 cc. of stock malachite green and 0.1 cc. of brilliant green, drop by drop. Incubate 3 hours and add 0.45 cc. of malachite green and 0.15 cc. of brilliant green and continue the incubation. The modification is very satisfactory.—*R. E. Thompson.*

Disposal of Industrial Wastes. JOHN D. RUE. Sewage Works J., **1**: 365-9, 1929. From Chem. Abst., **23**: 5529, November 20, 1929. Wastes from pulp and paper industry are discussed.—*R. E. Thompson.*

Can Lead Corrode? K. SCHERINGA. Pharm. Weekblad, **66**: 741-3, 1929. From Chem. Abst., **23**: 5462, November 20, 1929. Lead has been considered rustproof in consequence of the supposed formation of a superficial layer of suboxide. Specimens of lead water pipe, however, were found which showed deep corrosion with formation of a white or reddish yellow crust. The metal corrodes more rapidly when in contact with lime or cement. An oxidation occurs in the presence of air and a base such as lime or caustic alkali. Under these conditions the remaining metal becomes more active, possibly through recrystallization, so that it dissolved readily in 50 percent nitric acid, whereas recently melted lead is passive. The oxidation is catalyzed by the presence of lead monoxide.—*R E. Thompson.*

The Prevention of Corrosion. E. S. STOKES. Chem. Eng. Mining Rev., **21**: 432-40, 1929. From Chem. Abst., **23**: 5462, November 20, 1929. A review.—*R. E. Thompson.*

Electric Welding of Field Joints of Oil and Gas Pipe Lines. HAROLD C. PRICE. Am. Mining Met. Eng., Tech. Pub. No. **251**: 17 pp., 1929. From Chem. Abst., **23**: 5462, November 20, 1929.—*R. E. Thompson.*

Physicochemical Determinations on the Potable Waters of Milan. FILIPPO PRATO PREVIDE. Giorn. chim. ind. applicata **11**: 265-6, 1929. From Chem. Abst., **23**: 5520, November 20, 1929. The conductivity and freezing points of all of the potable waters supplying Milan were measured and the insoluble residues calculated from these data. The residues were also determined chemically. The results showed close agreement, the greatest variation being 0.375 gram found and 0.360 gram calculated.—*R. E. Thompson.*

Artificial Production of Ground Water. E. GROSS. Gas-u. Wasserfach, **72**: 901-5, 1929. From Chem. Abst., **23**: 5521, November 20, 1929. Methods are described of filtering river water through the banks, or from artificial infiltration basins, with preliminary clarification when necessary.—*R. E. Thompson.*

Further Contributions on the Differentiation of Organic Matter in Water. The Chlorine Combining Power of Ground Water. K. KEISER. Techn. Gemeindeblatt, **32**: 195, 1929; c.f C.A., **23**: 3999. From Chem. Abst., **23**: 5521, November 20, 1929. The chlorine demand of ground water gives valuable information concerning the kinds of organic matter present. The ratio of oxygen demand to chlorine demand varies greatly.—*R. E. Thompson.*

Sources of Error in the Determination of Organic Matter in Sewage by the Method of Kubel-Tiemann. F. REINHOLD. Techn. Gemeindelblatt, **32**: 215, 1929. From Chem. Abst., **23**: 5528, November 20, 1929. Very great errors may occur in the oxygen consumed determination. The principal sources of

errors are in the time of heating, character of material to be oxidized, effect of dilution, and the permanganate solution.—*R. E. Thompson.*

Occurrence of Silicates in Natural Waters. O. W. Rees. Ind. Eng. Chem., Anal. Ed., 1: 200–1, 1929. From Chem. Abst., 23: 5521, November 20, 1929. In Illinois, it is customary to determine calcium, magnesium, ammonium, sulfate, nitrate, chloride, and carbonate and to estimate sodium by difference in milli-equivalents between the cation and anion contents. Better results are obtained if the soluble silicate is added to the other anions.—*R. E. Thompson.*

The Bottled Mineral Waters. Investigations on Their pH and Their Content of Coli Bacilli and Other Bacteria. Jean Bance and Louis Caillon. Arch. Inst. Pasteur Tunis, 18: 199–201, 1929. From Chem. Abst., 23: 5525, November 20, 1929. The pH values of 21 (apparently French) bottled mineral waters ranged from 6.0 to 7.6. The number of bacteria per cubic centimeter was between 0 and 10 in 10 cases, between 10 and 100 in 5 cases, between 100 and 1000 in 3 cases and 400,000 in 1 case. Several of the waters contained a large number of molds. Only 1 brand contained colon bacilli (200–500 per liter).—*R. E. Thompson.*

Electroösmotic Water Purification. A. S. Behrman. J. Chem. Education, 6: 1611–8, 1929; cf. C.A., 22: 475. From Chem. Abst., 23: 5524, November 20, 1929. The demineralization of water may be carried to 10 p.p.m. with a 3-compartment cell. Water purified by electroösmosis compares very favorably with distilled water in purity. Commercial installations for ice manufacture are being developed. The only attention required is periodic cleansing every 2 weeks of the diaphragms by immersion, first in dilute hydrochloric acid and then in water.—*R. E. Thompson.*

Purification of Water by Electroendosmosis; The Preparation of Distilled Water by Electroendomosis. K. Illig. Chem. Listy, 23: 408–16, 1929; cf. C.A., 23: 459. From Chem. Abst., 23: 5524, November 20, 1929. Electrodistillation is not economical; electroösmosis requires a small space, simple apparatus, and little current. The hardness may be reduced to any degree. This article is primarily a review.—*R. E. Thompson.*

Water Purification by Base Exchangers. F. Diénert. Chimie & industrie, 22: 249–58, 1929. From Chem. Abst., 23: 5524, November 20, 1929. A brief review of the constitution and properties of artificial zeolites, and of their use and merits for softening water.—*R. E. Thompson.*

Deterioration of Concrete in Hydraulic Structures. Axel Ekwall. Concrete, 35: 4, 21–2, 1929. From Chem. Abst., 23: 5558, November 20, 1929. Permeability of concrete is given as the chief cause of deterioration.—*R. E. Thompson.*

The Treatment of Spent Gas Liquors. A. C. MONKHOUSE. Surveyor, 76: 37, 1929. From Chem. Abst., 23: 5562, November 20, 1929. Percolating filters have handled gas wastes containing 8 percent spent gas liquor without drop in filter efficiency.—*R. E. Thompson.*

Concrete Exposed to Alkali Ground Waters. J. C. MACKENZIE. Proc. Am. Concrete Inst., 25: 763–7, 1929. From Chem. Abst., 23: 4319, September 10, 1929. The significant findings of the past few years are: (1) the actions of sodium sulfate and magnesium sulfate, which formerly were supposed to be similar, differ materially and affect different cements in different ways; (2) concretes and mortars made from portland cements from different mills and from different raw materials may differ widely in their stability in alkali waters; (3) strength tests are not indicative of the relative sulfate resistances of different cements; (4) some high-alumina cements are very resistant to attacks by magnesium sulfate and are more resistant to sodium sulfate than most portland cements; but, on the other hand, they are quite easily attacked by sodium carbonate; (5) if even a lean concrete made from a cement of low natural resistance to alkali be steam-treated at a temperature not lower than 212°F. for a sufficient length of time, it can be made absolutely immune to attack by sodium sulfate and very resistant to attack by magnesium sulfate, and it is concluded that if a rich, strong, impermeable concrete made from a cement of high resistance to alkali be so steam-treated, it will not only be immune to attack from sodium sulfate, but will also be practically immune in magnesium sulfate waters. If the temperature be less than 212° such resistance is not developed and under certain conditions the resulting product may be made even less resistant.—*R. E. Thompson.*

The Electrolytic Protection of Iron. W. VAN WÜLLEN-SCHOLTEN. Metallbörse, 19: 1240–1, 1295–6, 1517–20, 1929. From Chem. Abst., 23: 4410, September 20, 1929. The CUMBERLAND process of protecting boilers, etc., from corrosion by employing an outside electric current to oppose that produced locally has not given satisfaction in certain (German) post-war vessels. Experiments were conducted with smooth and roughened iron electrodes in baths in contact with air, under H, and with air currents led through them. BAUER's recommendation for the protection of iron in such conditions gives about 0.050–0.067 milliamps per square centimeter; in the experiments were used 0.010, 0.025, 0.050 and 0.100 milliamps. per square centimeter. The current density 0.010 milliamps. per square centimeter was insufficient. Under H, a current density of 0.100 milliamps. per square centimeter was needed for prolonged protection of the iron. When air was led through the baths, a higher current density was needed than when the solution was quiet, but in contact with air. Losses in weight of the electrodes were determined with difficulty. After 20 to 24 hours, the potentials assumed constant values. The calculated and actual current densities required agreed very well.—*R. E. Thompson.*

The Mechanism of Corrosion. FRANÇOIS ROEKAERT. Aciers spéciaux, 3: 346–52, 1929. From Chem. Abst., 23: 4431, September 20, 1929. The author classifies corrosion as chemical, electrochemical, and atmospheric. Chemical

corrosion may result in coatings of oxides, chlorides, bromides, iodides, and sulfides. The effectiveness of oxide coatings in resisting further corrosion depends, in general, upon whether or not the oxide produced is greater or less in volume than the metal used in producing it. If the volume of oxide is the greater, corrosion is decreased. Electrochemical corrosion is of two types: (1) that which involves an electric current produced externally and (2) that which does not require the presence of an external electric current. Atmospheric corrosion is due to moisture and polluting gases.—*R. E. Thompson.*

Protection Against Corrosion. COURNOT. Bull. soc. franç. eléc., **7**: 692–706, 1928; Science Abstracts, **32B**: 81. From Chem. Abst., **23**: 4431, September 20, 1929. A review of electrochemical methods.—*R. E. Thompson.*

Experiences with Pipe Protection. C. H. WARING. Gas Age-Record, **63**: 485–6, 1929. From Chem. Abst., **23**: 4431, September 20, 1929. Protective coatings, the proper cleaning of the pipe surfaces, and methods of application of the coatings are discussed.—*R. E. Thompson.*

Methods of Covering or Coating Pipes to Prevent Corrosion. W. MOELLER, JR. Gas Age-Record, **63**: 675–6, 1929. From Chem. Abst., **23**: 4431, September 20, 1929. A general discussion.—*R. E. Thompson.*

The Place of the Complete Corrosion Survey in Industry. HENRY W. HOUGH. Gas Age-Record, **63**: 172–5, 181–2, 1929. From Chem. Abst., **23**: 4431, September 20, 1929. The methods for and the utility of a complete study of the sub-soil and other factors bearing on the corrosion of a pipe line, in connection with the application of sufficient corrosion-protective material, are carefully discussed.—*R. E. Thompson.*

Corrosion Surveys for Distribution Systems. HENRY W. HOUGH. Gas Age-Record, **63**: 859–60, 867, 1929. From Chem. Abst., **23**: 4431, September 20, 1929. A discussion of the methods and utility of the corrosion survey. [Cf. preceding abstract].—*R. E. Thompson.*

Pipe-Line Corrosion. B. B. LEGG. Gas Age-Record, **63**: 551–4, 1929. From Chem. Abst., **23**: 4431, September 20, 1929. Apparatus for the coating of pipe with pitch is described and the costs of the coating process and its practical corrosion-prevention results are discussed.—*R. E. Thompson.*

Methods of Testing Cast Iron. A. LE THOMAS and R. BOIS. Foundry Trade J., **41**: 19–21, 32, 46–8, 50, 65–7, 1929. From Chem. Abst., **23**: 4427, September 20, 1929.—*R. E. Thompson.*

The Organic Matter of Sea Water and Its Relation to Plankton Production. H. H. GRAN and BR. RUND. Avhandl. Norske Vidensk. Akad. Oslo 1926; Intern. Rev. ges. Hydrobiol. Hydrograph., **19**: 340, 1928; Wasser u. Abwasser, **25**: 225. From Chem. Abst., **23**: 4487, September 20, 1929. The use of potassium permanganate to determine the organic content of filtered and unfiltered

sea water by oxidation was studied. Reliable values for the true organic content of unfiltered water could not be obtained because of the plankton organisms and bacteria present.—*R. E. Thompson.*

An Iodine Survey of Nebraska. W. H. Adolph and F. J. Prochaska. J. Am. Med. Assoc., **92**: 258–60, 1929. From Chem. Abst., **23**: 4505, September 20, 1929. The iodine content of Nebraska water supplies ranged from 8.8 to 30.0 parts per 100 billion.—*R. E. Thompson.*

The B. Coli Content of Mineral Waters. L. Gabbano. Zentr. ges. Hyg. Grenzg., **18**: 773–4, 1928; Wasser u. Abwasser, **25**: 227. From Chem. Abst., **23**: 4516, September 20, 1929. In 6 mineral waters small numbers of *B. coli* gradually increased in number for several days; in very hard waters the rate of increase was less, while in soft water there was no increase. Chloride, nitrate, phosphate, and alkalinity were beneficial, while sulfate was inimical. *B. typhosum* died out in a few days in mineral water.—*R. E. Thompson.*

Mineral Analysis of The Waters of Kama and Its Tributaries. A. A. Varov. Bull. biol. Research Inst. Univ. Perm (Russia), 35–49, 1928. From Chem. Abst., **23**: 4516, September 20, 1929. Analyses are given. The dependence of electric conductivity of water upon its mineral content was established. —*R. E. Thompson.*

Determination of the Hardness of Water by Means of Soap Solution. G. Bruhns. Chem.-Ztg., **53**: 469–70, 1929. From Chem. Abst., **23**: 4516, September 20, 1929. A discussion of the method of Boutron and Boudet. —*R. E. Thompson.*

Contribution to the Preparation of Pure Chlorine Gas. H. Eckstein. Chem. Fabrik, 1929, 335. R. Wasmuht. Ibid., 335–6; cf. C.A., **23**: 2769. From Chem. Abst., **23**: 3538, September 20, 1929.—*R. E. Thompson.*

Water-Tight Concrete. A. A. Bryushkov and P. N. Shabluikin. Neftyanoye Khozyaistvo **16**: 561, 1929. From Chem. Abst., **23**: 4547, September 20, 1929. Water-tight concrete is prepared from mortar by the addition of up to 10 to 12 percent by volume of a mixture of mineral and fatty oil; and up to 30 percent of asphalt, tar, fuel oil, etc. An excess of this mixture increases the impermeability of concrete and decreases its strength. The process is covered by the Russian (Soviet) patent No. 4939, August 13, 1929.—*R. E. Thompson.*

Coal Storage Requires Special Attention to Avoid Fires. A. T. Ward. Iron Trade Rev., **83**: 1499–1500, 1506, 1928. From Chem. Abst., **23**: 4552, September 20, 1929. Careful directions are given for the storing of coal so as to avoid spontaneous combustion; also methods of inspection and care after storing.—*R. E. Thompson.*

Treating Waste Water from Reading Gas Plant. A. F. Kunberger. Gas Age-Record, **63**: 9–10, 1929. From Chem. Abst., **23**: 4554, September 20,

1929. The apparatus and methods used by the Consumers' Gas Company of Reading, Pa., to treat waste water and in particular to remove suspended tarry matter, are described in detail. The process is essentially one of the formation of a flocculent precipitate by adding copperas and, if necessary, lime or soda ash, followed by settlement and filtration.—*R. E. Thompson.*

Measurement of Fluids in Pipe Lines. I. H. ESCHER. Commonwealth Eng., **17**: 7-10, 1929. From Chem. Abst., **23**: 4981, October 20, 1929.—*R. E. Thompson.*

Studies of the Alteration of Bacterial Flora on the Storage of Polluted Surface Waters in the Tropics, with Special Reference to Clemesha's Method for Determining the Age of Pollution. J. K. HOLWERDA. Mededeel. Dienst. Volksgezondheid Nederl.-Ind., 1928, **17**: 410; Zbl. ges. Hyg., 1929, **19**: 6; Wass. u. Abwass., 1929, **26**: 98. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, **3**: 3, 85, March, 1930. According to several investigators, the danger of infection in a water can be better estimated by the difference in the glucose and lactose titers and the order of the disappearance of lactose-fermenting types, than by the warm blood coli-titer. After discussing the titer estimation and the methods of isolating the lactose fermenters, the author describes experiments in reservoirs with glass covers, and in closed reservoirs protected from light, with strongly polluted river water.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Fauna of Streams. Nature, 1929, **124**: 633. A note on an article by E. PERCIVAL and H. WHITEHEAD in J. Ecology, August, 1929, 282. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, **3**: 3, 85, March, 1930. The stream bed fauna investigated in the West Riding of Yorkshire have been classified into seven categories according to the nature of the bottom, and this is connected with the general succession of conditions in passing down a stream and therefore with the speed of flow. The fauna (of which detailed analyses are given) consisted of a few types which varied with the environment. In clean water, the density of population was chiefly controlled by rate of flow. A table of the ecological relationship of organisms to each other and to the fundamental foods is given.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

New Researches on the Sterilisation of Drinking Water Supplies. D. OTTOLENGHI and A. CEREDI. Igiene mod., 1928, **21**: 321; Zbl. ges. Hyg., 1929, **19**: 725. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, **3**: 3, 77, March, 1930. "An Italian stable chloride of lime preparation 'chlorante' has proved very suitable for the sterilisation of drinking water. For pure water quantities of chlorine under 1 mgm. per liter suffice for sterilisation. For waters containing much organic matter the chlorine content must be higher (7.5 to 15 mgm. per liter) in which case the taste must afterwards be removed with sodium thiosulphate."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

A Method for the Softening of Water. S. A. SANFORD. U. S. P. 1,705,589; Chim et Indust., 1929, 22: 497. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 3, 77, March, 1930. "A product containing barium fluoride will, when added to water, precipitate the bases which cause temporary and permanent hardness, without the addition of a coagulant."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

A Process for the Softening of Water by Base Exchange. K. MORAWE. G. P. 460,743; Chim. et Indust., 1929, 22: 497. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 3, 78, March, 1930. "The process consists of filtration through a layer of lignite. After the softening action has ceased, the lignite is regenerated by treating it with a solution of an alkali salt such as common salt."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Purification of Water in Holiday Resorts. A. GUILLERD. Rev. d'Hyg. et de Med. Preventive, 1929, 51,603. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 1, 5, January, 1930. The author gives an account of a simple method of purifying drinking water in places where there is reason to suspect the supply. The process advised is the addition of Eau de Javel. The different forms of commercial Eau de Javel (hypochlorite of soda) are described, and the methods of determining the necessary dose and of treating the water are described in detail. —*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Unique Water Purification Plant: Dual Process at Welbeck Colliery. Iron and Coal Trades Rev., 1929, 119: 217. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 1, 9, January, 1930. An illustrated description of a water purification plant recently erected at the Welbeck Colliery. By the treatment adopted, scale formation and corrosion are reduced to a minimum and concentration of boiler water is controlled to prevent wet steam due to priming. The water is first pretreated by lime and soda-ash and clarified through pressure filters, after which the domestic supply for the colliery village is taken off. The feed water for the boilers is further softened in a Boby (Azed base-exchange softener which removes the remaining hardness without altering the alkalinity. The soft water is delivered through a heat-interchanger (which receives the water from a continuous blow-down arrangement of the tubular boilers), and an exhaust-steam water heater to a live-steam feed-water heater and de-aerator in which it is boiled for several minutes. The boilers are equipped with Boby patent continuous safety blow-down. Detailed descriptions of the different units of the plant are given. The plant is designed to provide boiler control at a working pressure of 350 to 400 pounds per square inch or greater, and is capable of treating 360,000 gallons daily. The boilers have remained in perfect condition since its introduction.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Corrosion and Water Purification Problems in the Light of New Electrical Investigations. L. W. HAASE. Chem. Ztg., 1929, 523: 653. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 1, 14, January, 1930. A summary of a paper read at a meeting of the Verein fur Wasser-, Boden-u. Lufthygiene. The author describes how a water that is in equilibrium, that is, neither corrosive nor protective, can, under certain circumstances, form a protective coating. The formation of protective coatings is explained from the standpoint of present knowledge of chemical equilibrium and the danger to mains of accumulated deposits from the natural formation of such coatings is discussed.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Water Service in Holland. F. A. LIEFRINCK. Wasserkraft. u. Wasserwirthschaft, 1927, Nos. 10, 11, 13 and 14. The present development of public water supplies in Holland is described with much valuable detail. The history is briefly outlined. The peculiarities of Holland, geologically and hydrologically, are explained. A few of the leading features of the paper follow, but those interested in the history and development of water service would do well to possess themselves of the original. Of the 7.4 millions of inhabitants in January, 1926, 4.6 are served by 111 public water supplies, of which 80 (72 percent) are publicly, and 31 (28 per cent) privately, owned. Of the 390 towns and communes served, 45 depend on surface sources, 110 on dune water, 228 on other ground water; the remaining eight on combinations of these. Nearly one-half of the country lies below the 1 meter contour line (above mean sea level at Amsterdam) and would of course be inundated at every high tide and by every flood in the rivers but for the dunes and dykes. A result of the peculiar conditions is that under all the low area except in the dune district water is encountered quite near the surface the salt in which exceeds 400 p.p.m., the limit for acceptable drinking water. Suitable drinking water is therefore scarce over large districts and rural public supplies have been established on a large scale. The average consumption in the eight largest cities varied from 116 liters in Rotterdam to 53 in Haarlem. Marked improvement in the typhoid situation has resulted notably in the fen districts, from the introduction of reliable drinking water. The paper concludes with a discussion of water tower architecture, with illustrations of three desirable models. Two maps and seven graphs are given also two figures illustrative of equilibrium conditions between fresh and salt ground water, first thoroughly worked out by Herzberg at Nordnerney in 1901 and later by Pennink, a former director of the Amsterdam waterworks.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Water Supply Legislation. The Surveyor, 76: 1969, 358, October 18, 1929. The second report of the sub-committee appointed by the Advisory Committee on Water to consider the need for amending legislation has been published. There is a need, the committee finds, for a consolidated code, and recommendations for a new Waterworks Clauses Act has been made to include the best that has been adopted in recent Parliamentary practice.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Disposal of Industrial and Mining Waste Waters in Water Courses and the Responsibility of the Industries. WERNEBURG. Gas-u. Wasserfach, 1929, 72: 822. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 1, 32, January, 1930. "General regulations for the rights of the owners of land and water courses are found in para. 23 of the State Industrial Regulations (Vorschriften der Reichsgewerbeordnung) and para. 906 of the Book of Common Law (Burgerliches Gesetzbuch), which lay down the cases in which an owner can take action and the action which can be taken. In different districts, these matters are dealt with by district Water Laws, and a description is given of the parts of the Prussian Water Law concerning the responsibility of manufacturers as regards methods of preventing pollution, compensation for damages, and the right to demand passage for effluents to a suitable water-course. A paragraph in the Mining Law (Allgemeines Berggesetz) of Prussia deals with the rights of mine-owners. As an example of the working of the different laws, a case is described of a complaint brought by the town of Magdeburg against mine-owners for polluting with salt a source of water supply from Elbe."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Chlorine Demand and Bactericidal Effect of Chlorine in the Sterilization of Drinking Water. V. FROBOESE. Gesund. Ing., 1929, 52: 791. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 4, 111, April, 1930. The author discusses the methods used by different workers for estimating the condition of a water and the sterilising effect of chlorine and the connection between the oxidisability (potassium permanganate demand) and chlorine number of a water. The conclusion reached by some workers that the disinfectant action is confined to "free" chlorine and that "separable" chlorine has little effect, led the author to carry out several series of experiments on the effect of chlorine on river water and on tap water to which sewage after settling had been added. Tables of the results of these experiments are given.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Oligodynamic Sterilisation of Drinking Water by the Katadyn Process. F. KONRICH. Gesund. Ing., 1929, 52: 804. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 4, 111, April, 1930. The author discusses first the discovery of the oligodynamic action of metals and metal salts and the investigations of different workers into the process, which appears to be probably of a chemical nature, due possibly to the metallic ions, not in themselves but as oxygen carriers. The effect varies with different bacteria and can be weakened or increased by additions of different substances. A theory of the actual action on the living cells is also discussed and a table summarising the results obtained by different investigators is given. Krause's Katadyn silver, which is prepared by a blasting process, or precipitation on sand or procelain, and tests carried out with it, are described. An illustration shows the effect on a solid nutrient medium. In contact with a liquid medium, the Katadyn sand showed an action considerably more rapid and effective than that of other oligody-

namic bactericides. The action increased with increased quantities of sand and the time factor was of importance. Tests with water which had been in contact with Katadyn sand showed that it had attained a very considerable bactericidal strength. Slight differences in the precipitation of the silver or in the material on which it is precipitated make a difference in the process and different coli groups show different resistance. The work of other investigators is discussed and references to the literature are given.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Softening of Water and Removing Iron and Manganese Therefrom by Base-interchange, and Preparing the Requisite Agent Therefor. A. Rosenheim. B. P. 286-307; Chem. and Indust., 1929, 48, Brit. Chem. Abst., B. 962. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 4, 112, April, 1930. "The material with which water is brought into contact is formed of a metal oxide gel, or a silica gel, or a mixture of these, in which alkali oxides or metals or ammonium ions have been incorporated. For the purpose of incorporation the gels are treated with aqueous solutions of (1) caustic alkalis and ammonia, (2) alkaline reacting alkali-metal or ammonium compounds, or (3) basic reacting substances the cations of which are not those of an alkali metal or ammonium, with subsequent treatment by a solution of an alkali compound."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

The Estimation of Oxygen in Waters Polluted by Effluents of Certain Composition. L. W. Haase. Gesund. Ing., 1929, 52: 846. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 4, 114, April, 1930. "Effluents from the sulphite pulp process remove very rapidly all evidence of the presence of oxygen in a stream as shown by Winkler's method. This is due to the affinity for oxygen being stronger in sulphite than in the manganous hydroxide used in the determination. Under normal stream conditions, however, the oxidation of sulphite proceeds extremely slowly so that it is insufficient to account for the apparent disappearance of oxygen. The author here makes a preliminary announcement of an electric process by which the oxygen content of a liquid can be estimated under any conditions of external influence or composition. Waters in which no oxygen is discoverable by the usual process can be shown by this process to contain oxygen."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Outlines of Experimental Plankton Research. E. Naumann. Die Binnengewasser, 1929, 6: Nature, 1929, 124: 961. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 4, 115, April, 1930. "A summary of research methods in fresh water plankton laboratories and in the field. The aims of such laboratories are discussed and a brief description of the Swedish Limnological Laboratory at Aneboda is given. Full descriptions are given of the apparatus and reagents used, the testing methods, the regulation of the water, and the culture of plankton, and the terms connected with limnological study are defined."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

A Quantitative Closing Net for Catching Plankton Organisms. W. E. ALLEN. Science, 1929, 70: 506. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 4, 116, April, 1930. "A description is given of a net designed for the capture of plankton organisms which are too large for closing bottles. The net is cylindrical, the side walls being of cloth attached to a circular plate at the upper end and to a sliding wheel at the lower end. This wheel moves on a central rod and to close the net can be firmly fixed to a lower plate, from the centre of which water drains off into a detachable cup. The top plate has a central opening to avoid the entanglement of organisms while descending to the desired level and the release of a valve closes this opening and releases the sliding wheel which descends to close the net. The apparatus is described in detail and illustrated by a sketch."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Innovations in the Chemical Purification of Drinking Water and Information on the Present Application of Activated Carbon and Earth. O. KOENIG. Gas-u. Wasserfach, 1929, 72: 1065 and 1091. Summary of Current Literature, Water Pollution Research, Department of Scientific and Industrial Research, 3: 3, 73, March, 1930. A summary of a paper read at a meeting of the German Union of Gas and Water Experts, describing physical-chemical processes of purification, especially in connection with the supply to Magdeburg of Elbe water of very variable condition and composition.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Zawada Waterworks. VOM WASSER. Year book for water chemists and sanitary engineers, 3: Verlag Chemie G.M.B.H. Berlin W. 10. Description with pictures of water works of Zawada in Upper-Schlecia. **Experiences by the determination of water flow with the help of fluoresceine.** F. EGGER. Several apparatus are described. The water could be traced after a few hours for 3½ km., containing one part of color in 300 million parts of water. After 24 hours the color increased to 1:100,000,000. After 4 days the color reduced and after 10 days color in the water was 1:5,000 million. Without the apparatus color could not be detected when present in 1:20,000,000. **Operation experiences at the experimental Stuttgart Water Works in Purification of surface water containing humic acids.** R. ENGLER. Precipitation with alum—lime treatment, manganese removal by filtering through manganese-active-sand, taste removal with active carbon, and reduction in acidity by aeration and marble. After aeration water contained still 5 p.p.m. free CO_2. Filtration through marble at a rapid rate did not remove all free CO_2. **What right do we have to assume a definite relation between drinking water and epidemics?** HAYO BRUNS. The relation between typhoid epidemics and the degree of water purification is direct. The total numbers of organisms are of importance, especially in connection with the source of supply. The direct determination of typhoid bacilli in drinking water has been accomplished only in rare occasions. Bruns does not believe that single typhoid bacilli will cause in most cases sickness. Doubt whether filtered polluted water in thickly populated regions is free from organisms. A series of typhoid outbreaks are shown graphically and in table form and discussed in detail. The writer believes that proper chlorina-

tion can prevent epidemics and single cases. **Dechlorination of water with active carbon.** H. Pick. Experimental and practical results with active carbon show that with a given filter rate on definite carbon layers a constant percentage reduction of chlorine takes place, irrespective of the chlorine concentration at the beginning. De-chlorination follows, therefore, the equation for mono-molecular reactions. Sets of curves illustrate this. Different thicknesses of carbon layers through which the filtering velocity varied and with different sizes of carbon particles show that the filter should be as small and as high as possible and that the activity of the carbon is proportional to the surface of the carbon. In the discussion of the paper a number of investigators cite their experiences. **Disinfection of water with silver salts and Katadyn-silver.** W. Olszewski. Killing effect of small quantities of silver in water is considerable; time is a factor; not very effective in turbid water. Combination of silver with chlorine may be very effective for swimming pools. Relation between time and effectiveness is shown. **Water in ice manufacturing.** W. Steffens. Freezing causes changes in concentration of soluble substances in the water. Iron, chlorides and sulfate contents change greatly. Hardness of water plays a rôle. Magnesium salts cause greenish color, white flocs and colored striations depending upon whether the magnesium is in chloride or sulfate form. Calcium behaves similarly. Sodium salts make ice look inferior and retard freezing. **Turbidity, nephelometry and interferometry as aids in water investigations.** E. Naumann. Discussion of measurements of light absorption, colloid dispersions and colloidal solutions with a discussion of apparatus used. **A new method for pH determinations.** R. Czensny. Colorimetric method similar to the Bjerrum—Arrhenius apparatus, namely double wedge-shaped tubes. **Determinations of permanganate consumption and chlorine numbers in water containing iron.** W. Austen. Organic pollution is determined by B.O.D. but it does not show whether the organic matter is derived from feces. By simultaneous determinations of oxygen consumed and chlorine number valuable information is obtained regarding the degree of pollution by feces. It is stated in textbooks that ferro-salts, nitrites, etc., interfere with oxygen consumed determinations. Studies show that organic iron affects oxygen consumption and chlorine numbers but inorganic iron does not have the same effect. Great difficulties were encountered in the study which were not all overcome.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Progress in the Domain of Water Analysis, 1924–1928. H. Bach. Reprint from Vom Wasser, 3: Verlag Chemie, G.M.B.H., Berlin, W. 10. The author reviews the developments in water analysis from 1924 to 1928, including the subjects of hydrogen ion concentration, chlorine, iodine, phosphoric acid, lead, iron, manganese, aluminum, calcium, magnesium, hardness, ammonia, nitrates, nitrites, sulphuric acid, dissolved oxygen, biochemical oxygen demand, carbonic acid, organic matter, suspended matter and phenol.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Swimming Pool at Ocean Falls, B. C. G. S. Barry. Western Construction News, 5: 2, 48, January 25, 1930. A description is given of the design, con-

struction and operation of a 25-foot by 60-foot indoor swimming pool and appurtenances. The following subjects are discussed: Water supply and drainage; substructure design; superstructure design; balconies; dressing room and toilets; foot pools; childrens' pool; overflow (scum) gutter; steps and ladders; tiling; decoration; lighting; heating building fire protection; filling the pool; heating the pool; draining the pool; circulating system; hair catcher; filtering and coagulating; chlorination; suction sweeper; swimming pool tests. Accompanying the article are plans and cross section drawings of the swimming pool; a diagrammatic layout of the piping system; and several photographs.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Regulations Governing Detroit's Swimming Pools. City of Detroit, Department of Health Swimming Pool Review, Series 3, 11, 1, November, 1929. The Detroit swimming pool regulations are here given under three sections as follows: Section 1. Rules for Users of the Pool. These consist of eleven rules chiefly concerned with the requirements of a thorough soap bath prior to entering pool, use of toilet, suits, evidence of communicable diseases, and polluting of pool. Section 2. Responsibilities of Administration. This includes under various sub-sections the responsibilities of school principals, club managers, recreational directors, swimming instructors, the pool engineers and the health department. Section 3. General Regulations. Under this heading there are specified the temperature and bacterial standards and chlorine control. It is required that the water be not under 72°F. and not over 78°F., with air temperature not less than 3° warmer than the water and not in excess of 82°F., unless summer heat forces an increase in this respect. As to bacterial standards, it is required that total counts shall not be in excess of 200 per cubic centimeter and no organisms of the B. coli group. Where chlorine or its compounds are used O.T. testing sets must be provided and at least one person on duty at all times during use of the pools capable of making frequent residual chlorine tests, records of which must be filed with the Department of Health.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Vom Wasser. Year book for water chemists and sanitary engineers, 3: Verlag Chemie G.M.B.H. Berlin W. 10. Contains 22 papers dealing with water purification and sewage treatment. Discussion of the papers are included. **Present and future of water purification and sewage treatment.** H. BACH. Tendencies in water purification and sewage disposal and probable future direction is discussed. **Determination of pollution of fish waters through tars and phenols.** R. CZENSNY. Description with apparatus and chemicals needed for the determination of phenols by direct methods (without distillation), with distillation in water, sludge and plants. **Experiences in sewage chlorination.** K. VIEHL. In the discussion Ornstein brought out that the effectiveness of chlorine can be greatly increased by traces of copper. Killing of algae was accomplished with 2.5 p.p.m. Cl and 0.18 Cu where doses of 20 p.p.m. Cl or doses of 100 p.p.m. $CuSO_4$ had failed.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

The River Pollution Problem. Surveyor, 77: 1988, 309, February 28, 1930. (Abstract from British Ministry of Agriculture and Fisheries report for 1925–1928.) So far as salmon and fresh water fisheries are concerned, pollution of streams continues to dominate the situation in Great Britain. In the opinion of the Ministry, pollution has not diminished since the war, and unless curbed, the existence of fisheries will be impossible. The governing factor is the cost of sewage and industrial wastes treatment and of litigation.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

The Purification of Swimming Pools. Modern Methods Employed at Hammersmith. Munic. Eng. San. Rec., and Munic, Motor, 1929, 84: 680. Department of Scientific and Industrial Research, Water Pollution Research, Summary of Current Literature, 3: 4, 113, April, 1930. The open-air swimming pool at Bloemfontein Road, Hammersmith, has a capacity of 370,000 gallons. The water-purifying plant includes a cast-iron strainer box, with removable strainer, shunt feed apparatus for coagulant treatment with alumina-ferric and ammonia, four 8 foot 6 inch diameter closed pressure sand filters, cleaned with compressed air, electrically driven circulating pumps, manometer type, "Chloronome" for the addition of a measured trace of chlorine gas, about 1 part per 2,000,000 parts, and electrically driven centrifugal pump. The contents of the bath are complete circulated every six hours at the rate of 60,000 gallons per hour. The same water can be used for the whole season and still remain absolutely clear and sparkling and free from obnoxious bacteria. The history and a detailed description of the open-air bath are given.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Swimming Pool Regulation. Regulations for Design, Construction and Operation of Swimming Pools of the Indiana State Board of Health. Monthly Bulletin, Indiana State Board of Health, 33: 1, 209, January, 1930. The regulations as adopted by the Indiana State Board of Health follow generally those of the Conference of State Sanitary Engineers. A regulation not always followed in other states is one prohibiting any physical connection between the water in the pool or in the heating or circulating system, and any drinking water system.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Notes of the Geology of Water Supply. D. YORKE. Surveyor, 77: 1988, 303, February 28, 1930. The water supply of a given district depends: (*a*) on the rainfall, (*b*) on the amount of water lost by evaporation (being about 30 percent more on hilly or rocky ground than on flat lands), (*c*) on the water percolating to the underground strata (in England averaging about 40 percent) and (*d*) on the surface runoff. The relation between (*c*) and (*d*) is determined largely by the nature and structure of the rocks. Water-bearing strata are usually porous, the most important being the sedimentary and organically-formed rocks, such as sands, gravel, sandstone, chalk, limestone, etc. Some impervious rocks, if highly fissured, provide valuable water-bearing strata, such as some igneous rocks (granite) and metamorphic (quartzites, slates, etc.). Reservoirs should not be formed in valleys where porous strata are inclined in the direction of the valley, as the water will escape along the bed-

ding plane, probably in such quantities as to render the reservoir useless, and in addition would undermine the foundations of the dam or cause its subsidence or sliding. Most rocks are charged with water up to a certain height, termed the "water table," which fluctuates with the rainfall and geological conditions and is influenced by pumping from wells. It is never a plane surface. Of the geological factors affecting the water table level, the most important are folds, faults, thinning of strata, unconformities and intensive rocks and dykes. In sinking wells, porous igneous rocks should be avoided. For economical and successful well boring, good water-bearing strata should be interstratified with impermeable beds and should be free of intensive faults or dykes acting as dams for subterranean water.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

The Use of Ammonium Chloride-Citrate agar for Identification of Coli Bacteria in Water and Sewage. K. L. Pesch. Gesundh.-Ing., 52: 884 (1929). Chemical Abstracts, 24: 5, 1170, March 10, 1930. "B. coli of fecal origin do not grow in a synthetic medium containing NH_4Cl and citric acid. Such a medium is of value in distinguishing bacteria of this group."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Mosquito Control on Water Supply Reservoirs. Ernest W. Constable. Jour. N. C. Section, A. W. W. A., 7: 1, 19, 1929. Mosquito control on water supply reservoirs has much in common with control on waters impounded for other purposes. Such impounded water provides preferred breeding places for the malaria-carrying mosquito. Facts on breeding habits of mosquitoes are given. Generally used methods of control include cleaning up of ponds, fluctuating the water level, stocking with fish, and application of larvicides.—*W. H. Weir.*

The Ground Water Resources of the Crystalline Rocks of North Carolina. Jasper L. Stuckey. Jour. N. C. Section, A. W. W. A., 7: 1, 41, 1929. Complete records of depth, size, and flow on 592 wells were secured. Deep wells in the crystalline rocks yield an average of 25 gallons per minute. There is a gradual increase in volume as depth and size of well are increased. A diameter of 10 to 12 inches is more likely to increase the volume than great depths. At depths greater than 600 feet, possibilities of securing 50 gallons or more per minute rapidly diminish. Massive rocks that are much jointed yield more water than strongly sheared rocks such as slates and schists. The Triassic sandstones and shales of N. C. yield no more water than the average crystalline rock. In locating a well, records of drilled wells, nature and thickness of mantle rock, and outcrop of bed rock in vicinity should be carefully studied.—*W. H. Weir.*

Legislation and Decisions Affecting North Carolina Water Works. J. H. Bridgers. Jour. N. C. Section, A. W. W. A., 7: 1, 69, 1929. Discussion of legislation and of North Carolina Supreme Court decisions affecting water works from 1850 to 1929.—*W. H. Weir.*

A System for the Bacteriological Examination of Water. A. J. Salle. Jour. Bact., 20: 381–407, 1930. Medium devised is intended to make possible easy differentiation of *B. coli* and *B. aërogenes* groups of organisms. Careful review of the literature and of previous work on the problem is given. False presumptive *B. coli* tests are thought to be caused by bacterial symbiosis, aërobic spore formers, or anaërobic spore formers. Inhibitive action of various dyes and of various concentrations of bile, or bile salts, is discussed. Based upon experimental data, new broth for use in presumptive tests is suggested as follows: peptone, 15 grams; K_2HPO_4, 15 grams; KH_2PO_4, 3 grams; lactose, 15 grams; crystal violet (1:5000 solution), 21.5 cc.; water to make 2000 cc. Following differential solid medium is also given: peptone, 10 grams; K_2HPO_4, 3 grams; KH_2PO_4, 0.6 gram; lactose, 5 grams; agar, 20 grams; water, 1000 cc.; erythosine (2 percent aqueous), 20 cc.; methylene blue (1 percent aqueous), 20 cc.; bromcresol purple (1 percent alcoholic), 2 cc. Method for preparing dyes is also given in detail. Excellent results were obtained with strains of *B. coli* and *B. aërogenes* used in tests. Very high percentage (99) of confirmations of presumptives was found in testing 100 water samples: about 8 percent higher than with standard broth. Medium appears to compare favorably with standard broth for general use. The solid differential medium gives results at least 48 hours in advance of present second lactose confirmation tube. Excellent bibliography is appended.—*Edward S. Hopkins (Courtesy Chem. Abst.)*.

Comparative Rates of Stream Pollution under Natural and Controlled Conditions. H. W. Streeter. Ind. Eng. Chem., 22: 1343–8, 1930; cf. C.A., 22: 4687. Comparison in reduction of bio-chemical O demand in Illinois River and in artificial controlled stream at Cincinnati station is made. Rates of oxidation in this highly polluted river seems to be similar to those under controlled conditions in the experimental stream. Apparent rate of reduction in biochemical O demand is not necessarily criterion of true rate of re-oxygenation. Demand value of suspended material, immediate demand value of stream and of matters taken up from stream-bed are controlling factors. Large proportion of O demand of a stream originates from deposited material. While sedimentation decreases the immediate demand, it may, in course of time, raise the basic demand. Rates of oxidation measured in artificial stream channel were of "same order of magnitude" as for river with same "density of pollution."—*Edward S. Hopkins (Courtesy Chem. Abst.)*.

Some Observations of the Effect of Pollution Contributed to Streams. J. K. Hoskins and H. R. Crohurst. Ind. Eng. Chem., 22: 1340–2, 1930. Using characteristics of Ohio River between Cincinnati and Louisville as basis, this study was undertaken to determine polluting effect on a large stream of increasing population on its water-shed. Comparison of data for years 1914–15–16 with past year indicates that river at these points is in better condition now than it was at time of previous investigations. This is true although the available dissolved O has decreased. It is believed that interpretation of bio-chemical O demand results may often be influenced by errors in stream flow measurement, or by analytical errors of sufficient magnitude to lead to erroneous conclusions.—*Edward S. Hopkins (Courtesy Chem. Abst.)*.

Survey of the Pollution of Rivers and Lake in the Vicinity of Rochester, N. Y. Stuart E. Coburn. Ind. Eng. Chem., 22: 1336–40, 1930. General description of sanitary survey of bathing beaches on Lake Ontario during summar of 1929. Moderate pollution was present from discharge of Genesee River, Irondequoit sewage treatment plant, erosion of banks, and from bathers themselves. It was concluded that health hazard was negligible. As standard of quality, 100 organisms per cubic centimeter on presumptive test for colon-aerogenes group per single sample, was adopted for survey as limit which was not to be exceeded in more than 5 per cent of individual samples collected.—*Edward S. Hopkins (Courtesy Chem. Abst.).*

Report of the Water Pollution Research Board (England) for the Year ended 30th June, 1929. Dept. Scient. & Indust. Res., R. Robertson, Chairman., **with the Report of the Director of Water Pollution Research,** H. T. Calvert. From Bulletin of Hygiene, 5: 11, 857, November, 1930. In the second annual report, purification of beet-sugar factory effluents receives attention. A measure of success has been secured through use of percolating filters, which produce an effluent susceptible to re-use. Laboratory experiments indicate that in process of biological filtration, oxidation of sugar occurs in stages and that in each stage a particular group of organism has a part. The Director's report covers preliminary work on survey of River Tees and summarizes present knowledge of zeolite process of water softening. Coordination of efforts expended by various organizations and investigatory bodies is proceeding.—*Arthur P. Miller.*

Second Report of the Joint Advisory Committee (England) on River Pollution. The Reception of Trade Effluents into the Sewers of the Local Sanitary Authorities. Ministry of Health. H. E. Brooks. Chairman. From Bulletin of Hygiene, 5: 11, 857, November, 1930. Tendency of manufacturers to settle on rivers not already industrialized has produced pressing problem. Report sets forth position under the General Law, local legislation, and local practice. Such matters as right of access to sewers, regulation of flow, measuring of quantities, and riparian rights in volume of a river's flow are given attention. Committee is convinced that amendment of the General Law is needed.—*Arthur P. Miller.*

On the Eijkman Test for the Bacteriological Examination of Water. Mario Magalhaes. Archivos de Hyg., Rio de Janeiro, 4: No. 2, 1930. From Bulletin of Hygiene, 5: 11, 858, November 1930. Eijkman's method employs a glucose peptone medium, to which water under examination is added in proportion of 1 to 8; incubation is carried out at 46°C. It is claimed that in from 18 to 24 hours a distinction can be made between *B. coli* from cold-blooded and those from warm-blooded animals. In addition to being selective for *B. coli* it inhibits common water organisms and correlates satisfactorily with indol and citrate and uric acid utilization tests and may thus prevent condemnation of water in which *B. coli* present are of non-human or cold-blooded origin.—*Arthur P. Miller.*

Observations on the Stability of Chloiide of Lime, 'Stabilized' Chloride of Lime, and Perchloron in the Plains of Bengal. J. W. Tomb. Far Eastern Assoc. Trop. Med. Trans., Seventh Congress, British India, 1927. 3: 553–66 From Bulletin of Hygiene, 5: 11, 589, November, 1930. Adding 20 per cent dry quicklime to bleaching powder is said to stabilize the latter so that it will in hot climates, (1) remain dry, (2) not corrode tin, and (3) lose only a small proportion of available chlorine when exposed to the atmosphere. Investigations which are described in this article indicate that, although first two claims are valid, such mixture will deteriorate more rapidly at all seasons than simple chloride of lime.—*Arthur P. Miller.*

The Bacteriological Purification of Water by Means of Iodine. G. V. Contreras. Ann. d'Hyg. Pub., Indust. et. Sociale. 1930, 8: 218–41. From Bulletin of Hygiene, 5: 11, 859, November, 1930. It is claimed that iodine is preferable to chlorine and hypochlorites in water purification. The dosage determined experimentally is added in solution in potassium iodide and any excess removed by sodium thiosulphate. It has the advantages of being stable in solid form and in solution and of being subject to easy regulation. In connection with goiter, its use is desirable in certain districts.—*Arthur P. Miller.*

Chemical Precipitation of Humic Pigments. C. P. Mom. Meded. Dienst. d. Volksgezondheid in Nederl.-Indie, 1929, —8: 422–30. From Bulletin of Hygiene, 5: 11, 860, November, 1930. To clarify and remove humus pigments from peaty waters in East Sumatra, chemical precipitants are needed. Aluminium sulphate, using 100 mgm. per liter, is found to be effective when pH is 5; ferric chloride in same dosage is even more effective at pH of 3.5. Chlorinated copperas acts similarly to ferric chloride. The aluminium sulphate method is the best, for if ferric chloride is used, the acidity must be neutralized and any iron remaining in solution must be removed.—*Arthur P. Miller.*

The Disinfection of Water by Sodium Peroxide. W. A. Uglow and I. G. Petrenko. Ztschr. f. Hyg. u. Infektionskr., 1929, 110: 761–8. From Bulletin of Hygiene, 5: 11, 860, November, 1930. On the strength of results recorded in this article, it is stated that, next to chlorine, sodium peroxide is best chemical available for water purification processes. Water containing considerable organic matter needs but 0.07 gram of peroxide per liter and two-hour period of contact. After purification, however, residual hydroxide alklinity must be neutralized with citric acid.—*Arthur P. Miller.*

The Disinfection of Artificial Mineral Waters with Sodium Peroxide. L. Gabbano. Ztschr. f. Hyg. u. Infektionskr., 1930, 111: 372–9. From Bulletin of Hygiene, 5: 11, 860, November, 1930. Sodium peroxide does not leave an unpleasant taste in water when used as germicide. Dose of 0.3 gram per liter destroys *B. typhosum*, *B. paratyphosum* and *B. coli* within half an hour; treatment with 0.05 gram per liter is effective in four hours. The peroxide should act for the required time, after which neutralization of residual hydroxide may take place. In mineral waters, the carbon dioxide present is adequate for neutralization without unpleasant taste resulting.—*Arthur P. Miller.*

Essential Features in the Design of Sanitary Drinking Fountains. Public Health Reports, **46**: 4, 170, January 23, 1931. The conference of State sanitary engineers at their 1930 meeting adopted the following as essential features of design, construction, and operation of drinking fountains. (1) The fountain shall be constructed of impervious material, such as vitreous china, porcelain, enameled cast iron, other metals, or stoneware. (2) The jet of the fountain shall issue from a nozzle of non-oxidizing, impervious material set at an angle from the vertical. The nozzle and every other opening in the water pipe or conductor leading to the nozzle shall be above the edge of the bowl so that such nozzle or opening will not be flooded in case a drain from the bowl of the fountain becomes clogged. (3) The end of the nozzle shall be protected by non-oxidizing guards to prevent persons using the fountain from coming into contact with the nozzle. (4) The inclined jet of water issuing from the nozzle shall not touch the guard, thereby causing splattering. (5) The bowl of the fountain shall be so designed and proportioned as to be free from corners which would be difficult to clean or which would collect dirt. (6) The bowl shall be so proportioned as to prevent unnecessary splashing at a point where the jet falls into the bowl. (7) The drain from the fountain shall not have a direct physical connection to a wastepipe unless the drain is trapped. (8) The water supply pipe shall be provided with an adjustable valve fitted with a loose key, or an automatic valve, permitting the regulation of the rate of flow of water to the fountain so that the valve manipulated by the users of the fountain will merely turn the water on or off. (9) The height of the fountain at the drinking level shall be such as to be most convenient to persons utilizing the fountain. The provision of several steplike elevations to the floor at fountains will permit children of various ages to utilize the fountain. (10) The waste opening and pipe shall be of sufficient size to carry off the water promptly. The opening shall be provided with a strainer.—*R. E. Noble.*

Court Decision Relating to Public Health. Prevention of Pollution of Stream Used for Domestic Purposes. Public Health Reports, **45**: 50, 3070, December 12, 1930. Utah Supreme Court; Bountiful City *v.* DeLuca et al., 292 P. 194; decided October 10, 1930. Action was brought by Bountiful City to restrain defendants from keeping or grazing goats or other live-stock within 300 feet on either side of a certain creek, its tributaries, or sources of supply, some of waters of which were used by city and its inhabitsnts for culinary and domestic purposes, and from permitting such animals to drink out of such creek, its tributaries, or sources of supply, and from in any manner contaminating such waters. Bountiful City was within its statute rights in constructing works and enacting ordinances to protect same and in preventing pollution of streams from which city water supply is derived. Land used by defendants was only good for grazing. Judgment of trial court was in favor of city, and defendants appealed. Supreme court stated that proper disposition of the case involved question of whether the statute, ordinance, and decree amounted to a taking or deprivation of property without compensation or due process of law. Court came to conclusion that neither statute nor ordinance was "an unreasonable regulation when properly and reasonably applied and enforced." Court affirmed restraint part of the decree, but reversed judgment because restraint was without compensation.—*R. E. Noble.*

Water Uses for Plant Supply Systems. ANON. Power Plant Engineering, 35: 79–81, 1931. Automatic valves save water. Drinking water treatments include coagulation, filtration, chlorination, and distribution through a cooling system. Through drinking fountains, workmen will usually consume 2 to 3 quarts per man per eight hours.—*G. L. Kelso (Courtesy Chem. Abst.).*

Storage of Water in Industrial Plants. ANON. Power Plant Engineering, 35: 18–20. 1931. Tables for capacities of rectangular and cylindrical tanks and of pipes are given.—*G. L. Kelso (Courtesy Chem. Abst.).*

Controlling Flow of Water. ANON. Power Plant Engineering, 35: 16–18, 1931. Pumps used in industry for handling liquids fall into four general classifications: (1) pistonless, (2) reciprocating, (3) rotary, and (4) centrifugal. Efficient operation of motor-driven pumps depends largely on motor control. Valves and vacuum chambers must be suitably placed to protect pumps. Tables and diagrams for pump operation are given.—*G. L. Kelso (Courtesy Chem. Abst.).*

Capacity of Water Piping Systems. ANON. Power Plant Engineering, 35: 14–15, 1931. Quantity of water discharged from a pipe depends upon head. Total head may be divided into five parts: H, the velocity head; H_e, loss of head at entrance; H_f, loss of head through friction; H_o, loss of head due to obstructions; H_b, loss of head due to bends. Where T is time of closing of a valve in seconds in order that there will be no water hammer; L, length of pipe back from valve in feet; V, velocity in feet per second; P_o, static pressure at no flow; and P_1, static pressure during flow, then

$$T = 0.027\ [LV \div (P_0 - P_1)]$$

—*G. L. Kelso (Courtesy Chem. Abst.).*

NEW BOOKS

Transactions of the Twenty-sixth Annual Conference of State and Territorial Health Officers with the United States Public Health Service. Report of Investigation of Public Water Supply of Grand Forks, Grand Forks County, N. Dakota. I. W. MENDELSOHN. Public Health Bulletin 191: (U. S. P. H. S.), p. 33, October, 1929. Supply consists of rapid sand filtration plant taking water from Red Lake River. Intake pipe is laid for some distance in river. Ordinarily the filtered water is chlorinated, but on January 14, 1928, and for several days thereafter, prechlorination was in effect. Unpleasant taste and odor were observed about January 10. Analyses by North Dakota Public Health Laboratory showed contamination present on January 16, absent on January 17, but present again January 27. Filtration plant analyses showed contamination on January 14 and 15 on which days chlorine dosages were 6 and 7 pounds per m.g., respectively; 8 pounds was applied on January 18. Association of positive presumptive tests with negative Endo plates was a noticeable feature in both sets of analyses. From January 10 to 20 a large and unknown number of dysentery cases developed and city health officer ordered water boiled till further notice. Investigation disclosed breaks at each of the

two ball-and-socket joints in submerged section of intake pipe, permitting entrance of sewage and periodical subjection of filters to heavy loads. After repairs, objectionable tastes and odor disappeared. Further inspection revealed the following insanitary conditions: three different cross-connections; a drainpipe from treated water storage basin to river, subject at times of high river stages to reversal of flow; on storage basin roof, a ventilator with open sides and with door bottom flush with roof, permitting entrance of debris and seepage; a by-pass around filter plant, and inferior construction and improper location of intake. It was recommended that all cross-connections, the bypass, and the drainpipe be removed; that further cross-connections in the city be looked for; and that *ortho*-tolidin tests for residual chlorine be made at least three times a day and results used in conjunction with bacterial and other findings to govern chlorine dosage; all to be carried out at once.—*R. E. Noble.*

Transactions of the Ninth Annual Conference of State Sanitary Engineers, Held at Chicago, Ill., October 13 and 15, 1928. Public Health Service Bulletin **196**: March, 1930. *Report of the committee on pump specifications.* H. F. Ferguson, Chairman L. S. Finch, H. A. Whittaker, I. W. Mendelsohn and E. D. Rich. Report covers following points in detail: location and general considerations; materials and construction of (*a*) dug and bored, (*b*) double tubular drilled, (*c*) driven and single tubular drilled wells; and design of hand pumps. Committee accepted and the report as representing tentative minimum requirements for handpump wells and for approved sanitary pumps. *Cross-connections.* Report by A. D. Weston upon recent developments. Resolutions of the A. W. W. A. in 1925, of the Conference of State Sanitary Engineers in 1926, and of the New England Water Works Association in 1928 are quoted. *Report of the Committee on Water Purification and Treatment.* H. W. Streeter, Chairman, R. D. Bates, C. F. Catlett, H. B. Foote, H. E. Moses, J. H. O'Neill, S. T. Powell, F. H. Waring, and Abel Wolman. Census of water filtration plants, as authorized at 1927 conference, is to be extension of that compiled by Gillespie in 1925 and reported as of 1930. Members of committee are to participate in this work. No progress was made in collective study of efficiency of chlorination as a measure of water purification, as assigned to the committee, owing to absence of workable plan for correlating data from different laboratories. In meantime, chlorination data from 35 municipal filtration plants have been made available by U. S. P. H. S. surveys and otherwise and, in addition, results of systematic experimental observations extending over four years by Public Health Service engineers. [The data on efficiency of raw water prechlorination have been published in January 1931 issue of this Journal, pp. 22–49.—Abstr.] Memorandum was submitted giving suggested standardized procedure for collecting and compiling data on efficiency of chlorination in connection with water filtration, with illustrative forms, and including two useful tables computed by J. K. Hoskins for converting *B. coli* findings into form of "most probable numbers." *Report of the Committee on Sanitary Conservation of Streams.* Committee, composed of W. L. Stevenson, Chairman, F. C. Dugan, L. S. Finch, J. K. Hoskins, and Abel Wolman, was requested to develop a pattern sanitary law applicable to sani-

tary conservation and prudent utilization of our water resources. Inherent differences between each state's problems and constitutional provisions and those of its neighbors prevent drafting of bill equally applicable to each. To be worth while, such statutes must be practical, capable of enforcement, and intended simultaneously to protect and to improve streams without placing undue burdens upon municipalities and industry. In this connection, the economics of application and enforcement must not be overlooked. With these considerations in view, the following broad, general, fundamental ideas on legislation were submitted. *Purpose of Statutes.* (1) To protect waters now clean against menace to public health and otherwise, so far as is compatible with public interests and urban and industrial development. (2) To improve sanitary condition of waters now more or less polluted. (3) To render waters increasingly useful to public as: (*a*) sources of present and future public and municipal supplies; (*b*) sources of supply for industry and agriculture; and (*c*) places for recreation in suitable locations. *Scope of Statutory Jurisdiction.* (1) Sewage disposal and public sewerage. (2) Industrial waste disposal. (3) Pollution arising from development of natural resources. *Administration of Statutes.* Should generally be vested in State department of health. Latter, or the board, or commission, must command services of adequate bureau of engineering to study projects, conduct investigations, and make reports and recommendations on the manifold and diverse questions which arise. Adequate appropriations to finance such work are a primary necessity. Committee states that administration of statutes, powers, and duties should be beneficial, rather than harmful, and that their enforcement should be accomplished intelligently. It adds that statutes should be so worded and in such terms that court cases will be sustained even upon appeal. The end result of enactment and enforcement of such statutes should be money spent on construction, rather than paid into public treasury while nuisance continues unabated. For wilful stream pollution from inoperative concerns, a money fine is the only redress and acts as a deterrent to such a flagrant practice.—*R. E. Noble.*